SIGILLVM · VNIVERSITATIS · CALIFORNIENSIS
FIAT LVX
MDCCCLXVIII
EX LIBRIS
Agric. - Forestry
Main Library

FORESTRY PAMPHLETS
in
Pamphlets on forestry TENNESSEE
"

VOL. I

Preliminary Study of Forest Conditions in Tennessee. By R. Clifford Hall, Forest Service. Extract A from Bulletin 10.

2 Chestnut in Tennessee. By W. W. Ashe, Forest Service. Extract B from Bulletin 10.

3 Yellow Poplar in Tennessee. By W. W. Ashe, Forest Service. Extract C from Bulletin 10.

4 The Resources of Tennessee. By the State Geological Survey, Nashville, Tenn. April, 1915.

5 The Resources of Tennessee. October, 1915.

6 The Resources of Tennessee. January, 1916.

7 The Forests of Tennessee. By George B. Sudworth.

SD144
T5P3
v.1

Main Lib.
Forestry

10—A (Of Tenn. Geol. Surv. Series)

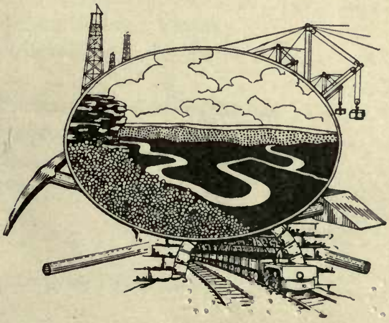
STATE OF TENNESSEE—STATE GEOLOGICAL SURVEY
GEORGE H. ASHLEY, State Geologist

IN COOPERATION WITH THE FOREST SERVICE
U. S. DEPARTMENT OF AGRICULTURE
HENRY S. GRAVES, Forester

PRELIMINARY STUDY OF FOREST CONDITIONS IN TENNESSEE

BY R. CLIFFORD HALL
FOREST ASSISTANT, FOREST SERVICE

EXTRACT (A) FROM BULLETIN NO. 10, FOREST STUDIES
IN TENNESSEE



NASHVILLE
McQUIDDY PRINTING COMPANY
DECEMBER, 1910

338455

The study upon which this report is based was undertaken by the Forest Service in coöperation with the State Geological Survey, the work being done under the direction of the Office of State Coöperation in the Forest Service and under the local instructions of the Director of the Survey. By the terms of the coöperative agreement the State is authorized to publish the findings of the investigation.

CONTENTS

PAGE.

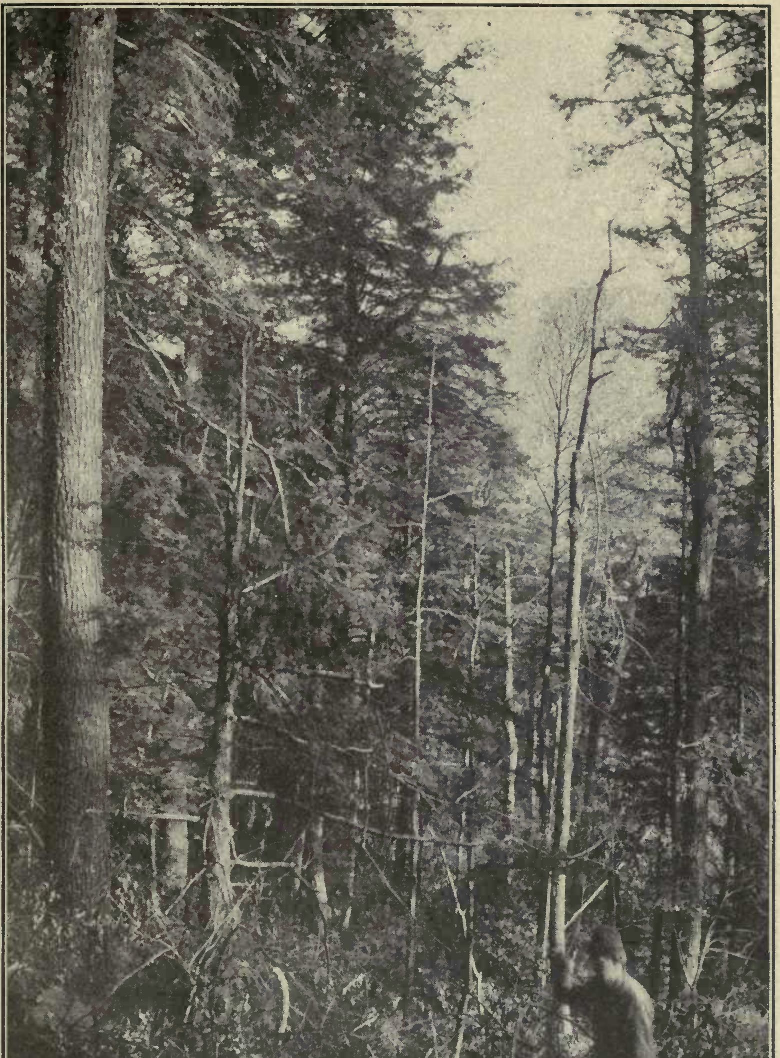
Summary 5
General conditions 6
Timber industries 8
  Stumpage values 8
  Saw timber 9
  Railroad ties 13
  Mine timbers 14
  Other products 14
Forest regions 17
  Unaka Range 19
    Coves 20
    Slopes 21
  Valley of East Tennessee 22
  Cumberland Plateau 24
    Coves 25
    Slopes 26
    Plateau swales 26
    Plateau ridges 26
  Highland Rim 26
    Slopes 27
    Ridges 28
  Central Basin 28
  West Tennessee Plateau and Bottom Lands 29
    Uplands 30
    Bottom lands 30
Forest problems 31
  Unaka Range and Cumberland Plateau 31
  Valley of East Tennessee and Highland Rim 34
  Central Basin 35
  West Tennessee Plateau and Bottom Lands 36
Forest policy for the State 37
  Necessity for action 37
  Proposed legislation 39

APPENDIX I.

List of tree species native to Tennessee 44

APPENDIX II.

Growth of white and chestnut oaks 50
  White oak 50
  Chestnut oak 54



Virgin Forest of Hemlock on Upper North Slope—Sevier County.

Preliminary Study of Forest Conditions in Tennessee

The bill establishing the Tennessee State Geological Survey specifies as one of its duties:

> "An investigation of the forests, . . . with especial reference to their conservation and development for industrial enterprises."

In accordance with this provision, the Geological Survey secured the coöperation of the Forest Service of the United States Department of Agriculture in a preliminary study of forest conditions in the State, the Forest Service paying one-half of the cost. The object of this study was to determine the forest resources and possibilities of the State, the legislation needed to secure protection and preservation of the forests, and the lines along which more detailed forest investigations can most profitably be carried out. In November and December, 1910, typical sections of each forest region were examined by a representative of the Forest Service, and interviews were obtained with public officials, lumbermen, and others familiar with local conditions. Considerable information was also obtained from reports on private tracts previously examined by the Forest Service.

SUMMARY.

The following is a brief statement of the results of the study and the conclusions drawn:

1. It is estimated that about 35 per cent of the total area of the State is in forest.
2. A large part of this land is best suited for growing timber.
3. It is of utmost importance, especially in the Unaka Range and the Cumberland Plateau, to conserve the forests that cover the steep slopes, not only for their timber supply, but also because of their protective value to the soil and their beneficial influence in regulating stream flow.

4. The forest land of the State is losing its capacity to produce valuable timber on account of forest fires and short-sighted, wasteful methods of cutting. Surface fires, which are very common throughout the State, in addition to burning the humus out of the soil and destroying the leaf mulch, kill young growth and injure larger trees at the butt, so that insects and rot can enter the wood and impair its commercial value. The usual methods of cutting are at fault in that too large a proportion of the tree is not utilized, and at the same time no provision is made for securing future crops. Both fire and repeated culling of the better trees result in the replacement of good timber by a comparatively worthless second growth.

5. Better methods of management should be instituted in order to increase the productiveness of forest land and to afford a permanent supply of raw material for the important wood-using industries of the State. By cutting old timber in such a way as to secure the restocking of the land with valuable species, by stimulating the growth of young timber by thinning out the inferior trees, and by other common-sense measures, the annual growth can be greatly increased and the possible lumber production of the future correspondingly augmented.

6. It is to the best interest of the State to promote the practice of forestry by adopting a progressive forest policy, including the employment of a State Forester, the establishment of a fire protective system, and the creation of State Forests. Such a policy has been adopted in whole or in part by twenty States.

7. The State Forester, in addition to administering the fire protective system and the State Forests, should engage in educational and research work, and in every way possible should assist the citizens of the State to make their woodlands more productive. He could do this by publishing simple and instructive pamphlets on various phases of forest management, by public lectures, by demonstration work on State Forests, and by preparing and superintending the execution of working plans for private forest lands upon request of the owners. It is impossible to overestimate the value of such work in bringing about a general use of more profitable methods of handling timber land.

GENERAL CONDITIONS.

The State of Tennessee presents a great variety of topographic and soil conditions. The eastern portion is mountainous in character and extends from the crest of the Appalachian Mountains westward over the western flank and foothill region of the Unakas, or Great Smoky Mountains, the Valley of East Tennessee, and the Cumberland Plateau. The rolling central portion includes the Highland Rim and the Central, or Nashville, Basin. The gently rolling western portion, lying between the narrow western valley of the Tennessee River and the Mississippi bottom lands, is known as the Plateau and Slope of West Tennessee.

The mean annual temperature for the State is about 59 degrees, varying from 57 degrees in the East to 61 degrees in the West. The average absolute annual range of temperature is about 90 degrees. The length of the growing season varies from about 175 days in the East to about 200 days in the West. The average annual precipitation is 50 inches, generally fairly well distributed. Thus climatic conditions are favorable to the growth of trees and other vegetation.

Transportation facilities by water are supplied by three great navigable rivers—the Mississippi, on the western boundary; the Cumberland, in the northern part; and the Tennessee, which crosses the State twice. These furnish about 1,200 miles of navigable waters, while a great many of their tributaries are also suitable for floating timber. In addition, there is a fairly well developed system of railroad transportation, with a mileage of over 3,600 miles.* Few portions of the State, even in the mountainous regions, are more than 25 miles from a railroad, and the greater part of the State is within 15 miles of railroad shipping points.

The larger part of the land in Tennessee is owned by farmers, and for the most part in small tracts, except in the mountainous portions of the State and in the Mississippi bottoms. In these portions larger bodies of land are often held by corporations or individuals, usually either for speculation or exploitation of their forest or mineral wealth. Here surface, timber, and mineral rights are frequently held by different owners. All of the larger bodies of virgin timber are owned by lumber companies. There is still considerable confusion in regard to land titles in the wilder parts of the State.

Taxation of timber lands has had but little influence upon forest management. While the present system is not ideal in principle or method of application, it has not resulted thus far in imposing an excessive burden on timber land owners as a class. Consequently there is little or no reason to believe that the cutting of timber has been hastened on account of taxes.

---

* "Statistics of Railways in the United States," Interstate Commerce Commission.

TIMBER INDUSTRIES.

The manufacture of lumber and timber products ranks second among the industries of Tennessee. In 1905 the value of these products amounted to over $21,500,000, while the capital invested was over $16,000,000. This is exclusive of planing-mill products, including sash, doors, and blinds, which in 1905 reached a value of over $4,500,000, with an invested capital of over $3,000,000. Fuel wood and a large amount of hewn and split material cut for local use would not be accounted for in these figures, although they constitute an important additional drain upon the forest. The consumption of firewood within the State is estimated at 4,730,000 cords for the year 1908. The most important products are rough and finished lumber of all kinds, railroad ties, staves and heading, vehicle stock, handles, poles, mine timbers, posts, and tanbark. The principal commercial timbers are oak, yellow poplar, yellow pine, red gum, chestnut, white pine, hickory, and hemlock.

STUMPAGE VALUES.

The value of standing timber depends on a number of different factors, chief among which are (1) the distance of the tract from market, (2) its accessibility for logging, and (3) the quality of the material. Since these are quite variable, any average figures, such as are given here, are of very general application, and are not suitable for valuing particular tracts. The stumpage values given for Middle and East Tennessee are based upon a distance from the railroad of from 8 to 12 miles, a haul which would be made in one day. In West Tennessee, where much of the timber does not command a price high enough to warrant long hauls, the basis of the figures is a two-trip haul.

White and red* oaks are about equal in value if the red oak is of the best quality. In many cases, however, the red oaks consist of inferior species which have a lower stumpage value. The largest amounts of white oak are produced in the Cumberlands, where it is worth about $5 a thousand feet on the stump. Similar timber in the Highland Rim, which also produces considerable white oak, is worth about $6 a thousand. The stumpage value of average quality red oak in Middle and East Tennessee is about $3.

---

* All merchantable black oaks are usually termed "red oak."

Yellow poplar is obtained from nearly every part of the State and brings from $3 to $5 more than white oak.

White pine is produced mostly in the eastern part of the Cumberland Plateau region, in the Valley of East Tennessee, and along the western borders of the Appalachian Mountains. It is usually worth about $2 or $3 a thousand on the stump.

Hemlock, which is obtained from the Cumberlands and Appalachian Mountains, is worth about $1.50 or $2 a thousand, including the bark, while white pine with a somewhat similar commercial distribution brings from $3 to $4 a thousand.

Chestnut is of commercial importance throughout Middle and East Tennessee, and usually is worth on the stump from $1 to $2 a thousand.

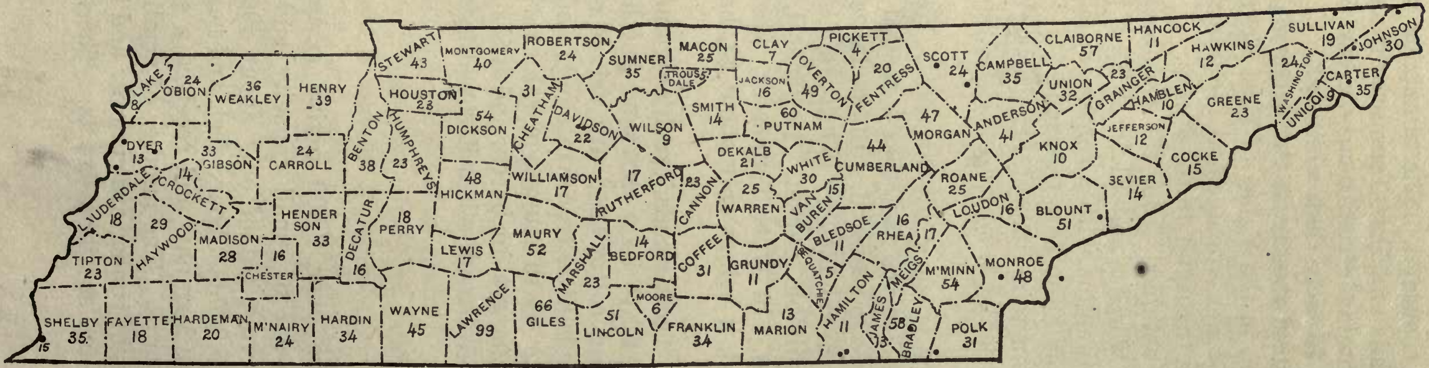
The value of hickory is especially uncertain, owing to its great variation in quality and to the fact that a special market and special methods of logging are required. In one large lumbering operation in the Cumberlands the hickory is left standing because of the difficulty of finding a suitable market. In general, it is worth from $2 to $5 on the stump. In West Tennessee, where the quality is as a rule not very good, it brings only about $3, based on a haul of two trips a day.

The West Tennessee " soft woods," such as gum, ash, and cottonwood, are worth from $2 to $4 a thousand on the stump. When sold separately, ash and cottonwood are valued somewhat higher than gum. Here there is little true white oak, and all the oaks are usually classed together as to stumpage value, which is about $6 or $7. There is little market for beech, and it is of no value unless located directly on the railroad, when it sometimes brings from $1 to $2 a thousand.

SAW TIMBER.

In 1909 there were over 2,500 active sawmills in Tennessee. Most of them were of small capacity and operated intermittently, with an average cut of only about 490,000 board feet. Only 33 mills cut over 5,000,000 board feet, and nearly half of these were located in or near Memphis and received a great deal of raw material from other States. The number of small mills is increasing as the larger bodies of timber are cut over and it becomes necessary to lumber small and scattered tracts. There is a great deal

MAP 1—TENNESSEE



SAWMILL STATISTICS, 1909.

Figures show number of active mills within the county.
Dots show the approximate location of mills that sawed over 5,000,000 board feet in 1909.

TABLE 1.—PRODUCTION OF LUMBER, LATH, AND SHINGLES, 1909.
(*Tennessee.*)

LUMBER.	THOUSAND BOARD FEET.	PER CENT.
Oak	546,500	44.6
Yellow poplar	164,826	13.5
Yellow pine	117,135	9.6
Red gum	75,565	6.2
Chestnut	71,962	5.9
Hickory	58,477	4.8
White pine	35,553	2.9
Hemlock	35,593	2.9
Ash	18,709	1.5
Beech	18,341	1.5
Cottonwood	12,380	1.0
Basswood	11,463	.9
Elm	10,688	.9
Cedar	8,927	.7
Cypress	8,709	.7
Maple	8,610	.7
Walnut	4,068	.3
Sycamore	3,512	.3
Tupelo	3,180	.3
Balsam fir	1,489	.1
Birch	1,274	.1
Cherry	874	.1
Spruce	720	.1
All other	5,294	.4
Total	1,223,849	100.0
Lath, M pieces	31,179	
Shingles, M pieces	35,692	

of waste connected with small mills owing to rough methods, wide saw kerf, lack of alignment in the machinery, and unskillful sawyers. However, they are at a great advantage in being able to move at small cost from one wood lot to another, thus saving the expense of hauling the logs. Where timber is so far from the railroad that only select logs could bear the cost of hauling in that form, a portable mill can move in and saw the inferior timber into lumber which can obviously be hauled to market at a much lower cost than in the log. Furthermore, the small mills can dispose of a certain amount of inferior lumber locally that could not be sold in the general market. This kind of lumbering will in time entirely supersede the larger operations. Some of the big sawmills claim a supply sufficient to keep them running for thirty or forty years, but these are very few in number.

Map 1 shows the approximate number of sawmills in each county and the location of the large mills for the year 1909. This map indicates very plainly the widespread character of the industry.

The amount of timber sawed in 1909 is shown by species in Table 1.* The woods classified as " all other " are chiefly buckeye, dogwood, and persimmon.

Waste in the manufacture of lumber is likely to occur both in the woods and in the sawmill. Very often timber is wasted in the woods by leaving high stumps, by cutting logs into such lengths as to leave merchantable timber in the tops, and by leaving trees uncut which ought to be removed. It would sometimes be possible to secure closer utilization by working the tops into ties, slack staves, or other small products for which there may be a market. Of course, in the more inaccessible districts where most of the large operations are carried on, it is usually impossible to handle anything but saw logs at a profit.

There is also great possibility for waste at the mill because of unskillful sawing, or lack of means for using slabs. Lath mills are often run in connection with the larger sawmills, thus utilizing material which would otherwise be wasted. The small mills are at a disadvantage in this respect, since they cannot afford to install the necessary machinery for making such by-products. Mills located in cities can usually dispose of scraps for kindling wood. A great deal of timber would be saved if boards were cut in odd as well as in even lengths.

---

* Compiled by the Bureau of the Census in coöperation with the Department of Agriculture, Forest Service.

RAILROAD TIES.

An important forest industry of Tennessee is the production of cross-ties. This furnishes a large market for timber which is too small and knotty for saw logs. Owing to the abundance of tie timber, there is at present little demand for other woods than white and post oaks, which are best suited for the purpose on account of their hardness and durability in contact with the ground. The best grades of these ties, delivered at the railroad, usually bring from 40 to 50 cents. In West Tennessee "soft woods," such as gum, ash, sycamore, elm, and maple, are bought to a limited extent at about 25 cents a tie. Red oak, beech, and cypress ties usually bring a few cents more. Of course ties of these species, with the exception of cypress, are treated with preservatives before using.

The railroads charge the same freight rate for ties as for lumber; and it is, therefore, usually impossible to sell them at a profit except to the railroad that serves the particular locality in which the timber is located, or to the tie company that buys for that railroad. This has a tendency to keep the price down. Where transportation by water is possible, as in the neighborhood of the Tennessee and Cumberland Rivers, higher prices can usually be obtained. As a general rule, the stumpage value of ties is not more than from 5 to 10 cents each, even for white oak, and a great many are cut and delivered for a return that will scarcely pay wages. In such cases the owners are willing practically to give the timber away in order to get work for themselves or their men at seasons when there is nothing else to do.

There are two principal sources of waste in tie making as commonly carried on: (1) Many trees are cut just at the time when they are putting on the maximum amount of valuable wood. Straight, thrifty trees large enough to make several ties are very easy to work up, and are, therefore, usually cut, although it is much more profitable to allow them to reach larger size before cutting. On the other hand, small trees of poor form, which could often be thinned from overcrowded stands to advantage, are not so easy to work up and are likely to be left by the woodsman. (2) A great deal of wood is wasted in hewing ties, especially if the timber is knotty. Most timber will yield about one-third more ties if they are sawed rather than hewed. Nevertheless, nearly 90 per cent of the ties produced in Tennessee are hewed, since conditions usually make this method the more practicable. Hewed ties are preferred by most of the railroads; and even though no difference in price is made, inspection is likely to be much less rigid, so that a slightly undersized or defective tie will be accepted if hewed when it would be rejected if sawed. Also it is somewhat less expensive to make and deliver a hewed tie, if the amount of timber wasted is not considered. Sometimes mine props and cordwood can be made from the tops of tie trees, thus saving wood which would otherwise be wasted.

MINE TIMBERS.

One of the principal uses for second-growth timber within the Cumberland Plateau is in connection with the coal mining industry, which is of great importance in that region. Timber of low grade and small size is suitable for props, caps, and mine ties, which are usually either round or split. Red oak and chestnut are the chief woods used for these purposes. Considerable saw timber is also used inside the mines for brattice, rails, and other purposes, and outside for the construction and repair of trestles and tipples. The number of props required varies greatly with the character of the rock covering which forms the roof of the coal seam. An investigation of the amount of timber used by coal mines in Eastern Kentucky showed an average consumption of about 4½ board feet per ton of coal mined. On this basis the amount of timber used in mining coal in Tennessee for the year 1909 would be 27,930,000 board feet. Of course a large part of this timber consists of material too small to make lumber.

OTHER PRODUCTS.

The manufacture of tight cooperage stock, for which white oak is the chief wood required, reaches its greatest importance in the Cumberland Plateau region. Elm and hickory are commonly used for hoops. A high grade of timber is consumed in making tight staves, and a great deal of the tree is wasted, especially if the staves are split out in the woods. In the manufacture of slack staves, on the other hand, close utilization is the rule. Oak, gum, and cottonwood are the chief woods used, and are taken largely from the bottom lands of West Tennessee. Table 2 shows the production of cooperage stock in 1909.*

Boxes and box veneers are also produced in considerable amount. In East Tennessee yellow poplar is used for this purpose, especially

---

* Compiled by the Bureau of the Census in coöperation with the Department of Agriculture, Forest Service.

TABLE 2.—COOPERAGE STOCK.

Production of Slack Cooperage Stock in Tennessee, 1909.

PRODUCT	TOTAL	Oaks	Red Gum	Cotton-wood	Yellow Poplar	Elm	Ash	Syca-more	Cedar	Bass-wood	Maple	Tupelo	Chest-nut
STAVES (thousands)	67,127	20,906	18,869	15,975	4,685	2,803	1,607	1,249	643	300	90	......	......
HEADING (thousand sets)	3,145	508	431	525	865	247	......	10	1	......	......	438	120
HOOPS (thousands)	13,130	15	50	......	......	13,060	......	......	5	......	......	......	......

Production of Tight Cooperage Stock in Tennessee, 1909.

PRODUCT	TOTAL	Sawed	Bucked and Split	Hewed	Beer and Ale
STAVES (thousands)	35,744	34,345	278	4	1,117
HEADING (sets)	3,694,532	3,615,557	......	......	78,975

in making cigar boxes. In West Tennessee gum and cottonwood are extensively used for veneer boxes, while considerable elm is shipped to New Albany for manufacture into baskets. Close utilization is also the rule in this industry.

The production of tannic acid centers in the Valley of East Tennessee, although the neighboring regions are drawn upon for raw material. Hemlock and chestnut oak bark and chestnut wood are the chief native sources. Oak bark is worth about $9 a cord delivered on the cars, and hemlock bark about $8. Chestnut wood is bought at from $3 to $4 a cord of 5-foot wood delivered on the cars. This industry is beneficial to conservative forest management, since it affords a market for chestnut timber which is too old and defective for lumber and which should be removed for the good of the forest. The bark is also a profitable by-product in the manufacture of chestnut oak and hemlock lumber.

Vehicle stock of all kinds is manufactured extensively from oak and hickory, especially in Middle and West Tennessee. Spokes constitute the most important product of this class. For heavy wagons, white oak is used, while for light wagons and buggies hickory is preferred. Red (willow) oak is also cut in West Tennessee for cane-cart spokes. As a rule, timber from 14 to 22 inches in diameter is preferred for these purposes. The billets from which the spokes are turned are either split in the woods or sawed from bolts at the mill. While the split billets make a better grade of spokes, there is more waste in making them, since fewer cuts are taken from the tree. Even at best there is a great deal of waste in the use of hickory owing to the discrimination against heartwood and bird-peck wood.

Another special use for hickory is the manufacture of tool handles, which constitute an important product in many parts of Middle and West Tennessee. Among other minor products made from hickory are skewers, picker sticks, and weaver frames.

The production of red cedar for pencil wood, piling, and posts centers in the Central Basin, more particularly in Wilson and Rutherford Counties. Other important red-cedar counties are Marshall, Giles, Bedford, and, in part, Maury and Fentress. Red-cedar lumber of average quality is worth about $35 a thousand feet at the railroad, while the best grades run as high as $50. The average stumpage value is about $20 for saw logs. Pencil factories are located at Murfreesboro, Lebanon, and Nashville. The supply of wood suitable for this purpose is so scarce that these factories buy logs from old cedar barns and fence rails, in some cases paying as high as 10 cents a rail in addition to putting up a new wire fence. Piling and posts of different sizes are also produced in large numbers. About 20 cents is paid for a 7-foot post 3 to 5 inches in diameter at the top. Black locust is also cut for fence posts in many parts of the State.

The strong demand for chestnut poles makes a wide market for straight second-growth timber of this species, which is valuable for the purpose on account of its light weight and durability. The poles are probably produced in greatest quantity on the western side of the Cumberland Plateau. Prices vary greatly with the size.

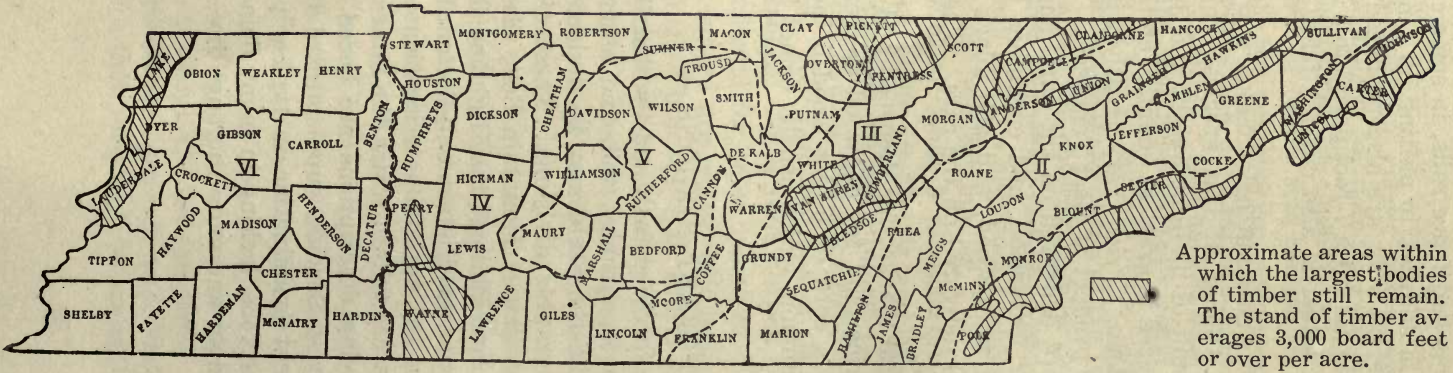
Pulp wood is a minor product of East Tennessee. Hemlock wood is worth about $4 a cord delivered on the cars, and is shipped to Canton, N. C. Poplar, basswood, and cucumber tree are worth about $5.50 a cord for pulp wood, and ash, black gum, and soft maple about $1 less, all delivered on the cars. These woods go to Bristol for manufacture.

There is also a general market for dogwood and persimmon for shuttle blocks. The price paid for dogwood delivered at the railroad is from $7 to $8 a cord of 5-foot wood 5 inches and up in diameter, and for persimmon, which usually comes in larger sticks, from $5.50 to $7 a cord.

FOREST REGIONS.

The character of the forest growth and the distribution of woodland depend chiefly on topography, soil, and other physiographic influences. Accordingly, the State may be divided into forest regions based on physiographic divisions. These divisions are the Unaka Range, or Great Smoky Mountain Belt, the Valley of East Tennessee, the Cumberland Plateau, the Highland Rim, the Central Basin, and the West Tennessee Plateau and Bottom Lands. The accompanying map shows the approximate location of the forest regions, and also of the areas within which the largest bodies of timber occur. The following descriptions are based on information in the files of the Forest Service, supplemented by brief studies made during the present examination in typical portions of each region. They are, therefore, lacking in many details which would be brought out by a longer and more thorough investigation.

MAP 2—TENNESSEE



▨ Approximate areas within which the largest bodies of timber still remain. The stand of timber averages 3,000 board feet or over per acre.

FOREST REGIONS.

I. Unaka Range.
II. Valley of East Tennessee.
III. Cumberland Plateau.
IV. Highland Rim.
V. Central Basin.
VI. West Tennessee Plateau and Bottom Lands.

UNAKA RANGE.

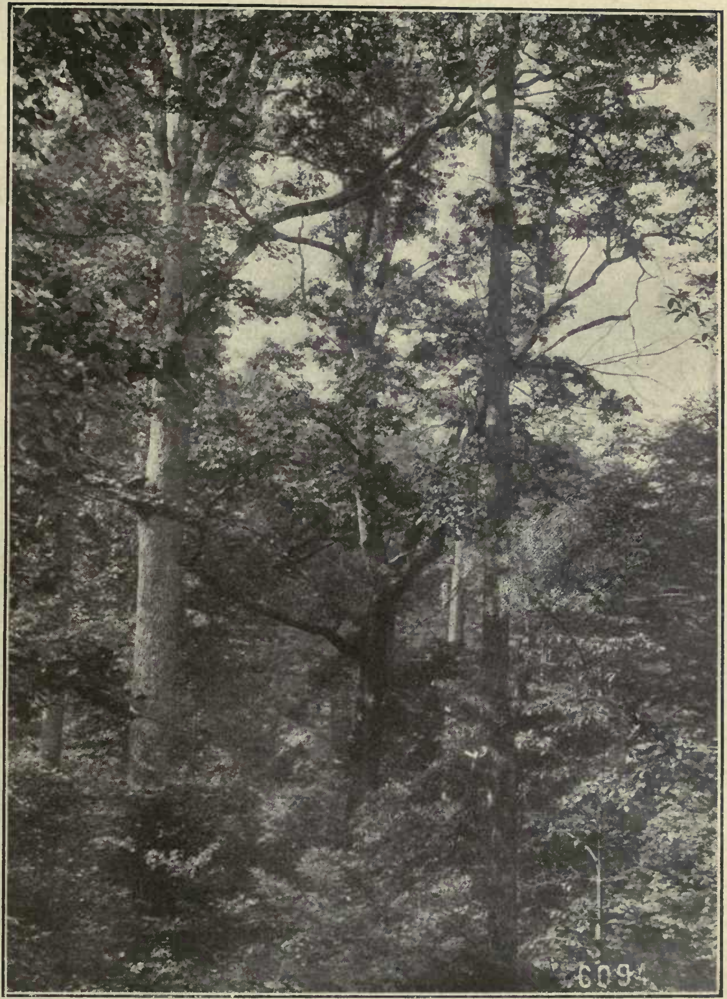
The Unakas constitute a region about 2,000 square miles in extent in the form of a belt averaging 13 miles wide, which extends northeast and southwest and forms the eastern border of the State. The general elevation varies from 1,500 to 5,000 feet, but some of the higher peaks reach over 6,000 feet above sea level. The country is drained westerly by swift mountain streams tributary to the Tennessee River, some of the larger of which rise in North Carolina and cut through the range in deep and narrow valleys. There is very little level land and practically no swamps. Small farms are found along the streams and in the broader coves, mostly in the western part of the region, but the greater part of the land is too steep for cultivation.

This region is crossed at four points by railroad lines, which connect with the north and south trunk lines extending through the Valley of East Tennessee. It is also penetrated by several logging railroads. There are, however, portions of the high ridge along the North Carolina line which are still very inaccessible. Such portions are usually covered with virgin timber, although sometimes the best of the poplar and walnut has been cut and floated out at flood seasons. A considerable proportion of the land is held in large bodies, principally by lumber companies. The smaller holdings are confined chiefly to the foothills and valleys which are most accessible and best adapted for farming.

The chief industry throughout the region is lumbering, although copper mining is of local importance in the southeastern corner (Polk County). In addition to the small portable sawmills occasionally found in the more accessible parts, there are about five lumbering operations in virgin timber, with large sawmills supplied by logging railroads. A large amount of hemlock, poplar, oak, and other lumber is produced. Minor products include chestnut oak and hemlock tanbark; chestnut and, to some extent, chestnut oak extract wood; and, in the northeastern part of the region, pulpwood made from the smaller sizes of poplar, cucumber, basswood, and hemlock. Other woods are sometimes cut for special purposes, such as sugar maple, beech, and birch for bobbins, and dogwood and persimmon for shuttle blocks. Some white oak cross-ties are also produced.

The forests cover nearly all the rough, steep mountain slopes and higher coves of the region. Virgin timber, however, is confined to the most inaccessible sections, the largest bodies occurring in the eastern parts of Sevier, Blount, and Monroe Counties. The cut-over lands are covered by irregular, uneven-aged stands of defective and suppressed old trees mixed with young growth. Even-aged, second-growth forests are found only in the vicinity of old iron furnaces or on old fields where clear cutting took place. The most important commercial timbers are yellow poplar, hemlock, and chestnut, although a great variety of valuable hardwoods as well as white pine and spruce are also found. Altitude and exposure are of great importance in determining the character of the forest. Two broad types may be distinguished—coves and slopes. While the slope type comprises a much larger proportion of the territory, the coves are of greater commercial importance, since they contain by far the heavier stands and better quality of timber. A survey of a tract of 110,000 acres in Polk and Monroe Counties shows 12 per cent of the total area to be cove land.

Coves.—The cove type includes the sheltered belts along drainage lines and the hollows at headwaters of creeks and branches. The soil is deep and fertile, with a constant and even supply of moisture. Yellow poplar and hemlock are the characteristic trees of the type, the former comprising from 3 to 10 per cent of the stand and the latter from 25 to 50 per cent. The associated species include chestnut, birch, basswood, hickory, white pine, maple, red and white oaks, buckeye, and cherry. At the higher elevations the proportion of hemlock, birch, maple, and cherry increases at the expense of yellow poplar, oak, and chestnut. Yellow poplar, chestnut, and white pine occur as dominant trees singly or in small groups, their crowns reaching above the tops of the other trees. In virgin stands the ground is usually covered with a deep humus and a good accumulation of litter, since ground fires are not frequent in this type because of the moisture. A scattering undergrowth is usually found, chiefly of hornbeam, holly, beech, dogwood, and witch hazel. Reproduction of oak and chestnut takes place where light is admitted through openings in the crown cover; while scattered seedlings of the more tolerant trees, such as hemlock, birch, basswood, beech, and maple, are found here and there under the older trees. Because of the fertility of the soil and the prevalence of a good moisture supply, the trees are of good form, with long, straight trunks, clear of branches to a great height. Virgin stands in this type will average from 8,000 to 10,000 board feet to the acre over extensive areas, while individual acres will, in some cases, yield from 20,000 to 35,000 feet. Thrifty second-growth



White and Chestnut Oak on West Slope—Polk County.

stands are rare. When the cut-over lands have not been used for farming, as is sometimes possible, they have usually been so severely burned that natural tree reproduction is inferior in amount and quality.

Slopes.—The long, undulating slopes and narrow ridges are covered with many local forest types in which different species predominate. At the lower elevations, chestnut, chestnut oak, black, scarlet, and white oaks, hickory, and sometimes scrub and short-leaf pines, are the chief trees. Chestnut is very often the predominating tree, preferring northerly slopes; while scarlet, or chestnut, or white oak sometimes predominate, especially on southern exposures. White pine also grows on the northerly slopes at the lower elevations. Scarlet oak is most commonly found along the foothills just above the limestone outcrops. At higher elevations (above 2,000 feet on Little River) pitch pine is found on the more exposed southern slopes in patches that mark the poorer situations. Here white oak is largely confined to the warmer sites, such as the lower, less exposed ridges and the flatter south slopes. Chestnut oak is also found on such situations, and is abundant on nearly all the ridges and upper slopes of medium elevation. At the higher elevations, especially on slopes with northern and eastern exposures, beech, cherry, basswood, and buckeye are the most important hardwoods. Spruce begins to appear at elevations as low as 4,000 feet, on shallow, stony soil, but reaches its best development above 5,000 feet. It is associated with beech, yellow birch, and maple, and at the very highest elevations with balsam.

The direction toward which the slope faces has a great influence upon the size of the trees and the amount of merchantable timber as well as upon the composition of the stand. The south and west slopes receive the direct rays of the sun during the hottest part of the day, as well as the full force of the prevailing winds of summer. They are, therefore, more subject to drought, to wind break, and, since growth starts earlier in the spring, to frost damage, than the more sheltered north and east slopes. The soil is also thinner and less fertile, due partly to the action of the wind in blowing the leaves up the slopes and over the ridges so that they cannot decompose and enrich the soil. Consequently, the timber is smallest and of poorest quality on south slopes, and usually consists of trees best able to endure such unfavorable conditions, among which chestnut oak is most abundant, with chestnut next. White and black oak, hickory, short-leaf pine, sourwood, and black gum are also typical of such situations. On the other hand, the north slopes are characterized by a greater variety of species, and the sheltered lower portions are classed with the cove lands. The more exposed ridges are usually covered with a stunted, scrubby growth of the hardiest trees and shrubs.

There is considerable damage to timber from fires, especially on the drier, southwest slopes. The burned-over land often becomes covered with briers, laurel, rhododendron, and other shrubs, which choke out tree reproduction. Fires are set purposely by cattlemen to improve grazing, and accidentally by hunters and campers. Cut-over lands are always in danger from fire because of the slash left after lumbering. Sometimes the impetus gained by a fire on such lands will carry it into virgin stands which would not ordinarily be in danger. For this reason lumber companies often make an effort to keep fire out of their cut-over lands.

VALLEY OF EAST TENNESSEE.

That portion of the Great Appalachian Valley within the State forms the Valley of East Tennessee, a belt lying west of the Unakas with an average width of 50 miles, a general elevation of 1,000 feet, and an area of 9,200 square miles. It is made up of a series of minor valleys and low ridges which rise from 300 to 500 feet above the stream levels. The long, northeast-southwest valleys are underlaid by limestone and shale. The intervening ridges formed by standstone strata are either narrow and sharp-crested or mountainous in character; while the cherty dolomite ridges are broad, with rounded or level tops. The entire region is drained southwestward by the Tennessee River and its tributaries. These become smaller and swifter above Knoxville, where the general slope is somewhat steeper. The railroad transportation facilities are very good, with two trunk lines south of Knoxville and one north. Most of the land is held in farms of moderate size, although there are also a few large tracts owned by individuals or corporations.

This is a well-settled region in which agriculture is the chief industry. The timber is of relatively small commercial importance, since the virgin stands have long been cut off and little has been done to encourage and protect second growth. Nevertheless, there are many portable mills producing inferior grades of lumber, chiefly for local use, and a considerable amount of wood is cut for fuel and extract purposes. Cross-ties and chestnut poles are also produced. Within the region are several cities where various manufacturing

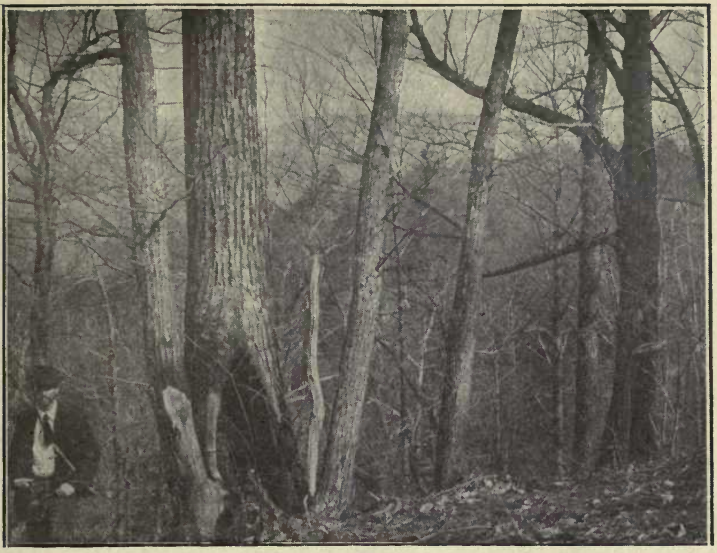


FIG. A.—EFFECT OF SURFACE FIRES ON CHESTNUT—MONROE COUNTY.

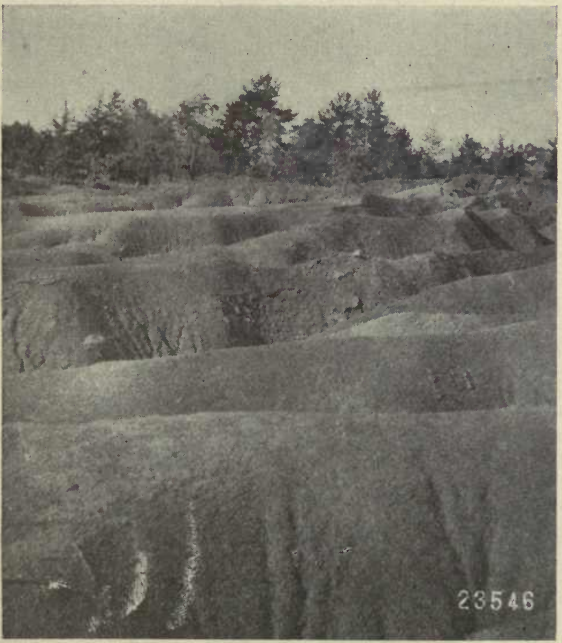


FIG. B.—EROSION OF CLEARED LAND—BLOUNT COUNTY.

industries center which use timber both from this and adjoining regions. In addition to planing mills, furniture and box factories, there are tannic acid plants using both wood and bark, handle and spoke factories, and other wood-using industries. Practically all of the higher grade timber comes from the mountains.

The forests are very broken in distribution, being largely confined to the crests and steeper slopes of the ridges; many of the broader ridge tops, as well as the valleys, are in cultivation. The stands are, for the most part, uneven-aged, except on old fields and on tracts which have been cut clear for charcoal or fuel. The trees are generally from 7 to 18 inches in diameter, with the exception of an occasional old chestnut or other tree which is considered too hollow or decayed to be worth cutting. The silvicultural condition of the forest is poor owing to the prevalence of fire, the grazing of hogs, and the continued culling out of the best trees.

The forest may be divided into two original types—ridge and slope; and one temporary type—old field. The ridge type includes the ridge tops and the upper south slopes, while the slope type is found on north slopes and the more fertile and sheltered southern exposures. Chestnut oak and chestnut are the characteristic trees of the ridge type, although black and Spanish oaks sometimes predominate, especially on high flats. Other common trees of this type are scarlet and post oaks, pignut hickory, black gum, and short-leaf and scrub pines. The slope type is characterized by red oak, white oak, and yellow poplar, with which are associated chestnut, hickory, maple, butternut, an occasional walnut, and many other hardwoods.

The old-field forests are usually found on lower slopes or on ridge tops which were once cleared for agricultural purposes. The first woody growth on old fields is usually pine, sassafras, and persimmon; but later the composition becomes more similar to the original type, except that there is in most cases a much higher proportion of short-leaf and scrub pines. Sometimes the pine reproduces in practically pure stands, while it very often forms groups covering from 20 to 50 per cent of the area. In the original types, pine is confined to the poorer situations and rarely occupies more than from 10 to 15 per cent of the ground. The proportion of short-leaf to scrub pine on the old fields varies greatly, and seems to be determined chiefly by the proximity of seed trees of one or the other species. Possibly a little over one-half of the old-field pine in the southern counties consists of the more valuable short-leaf pine, while in the northern counties about three-fourths is scrub pine.

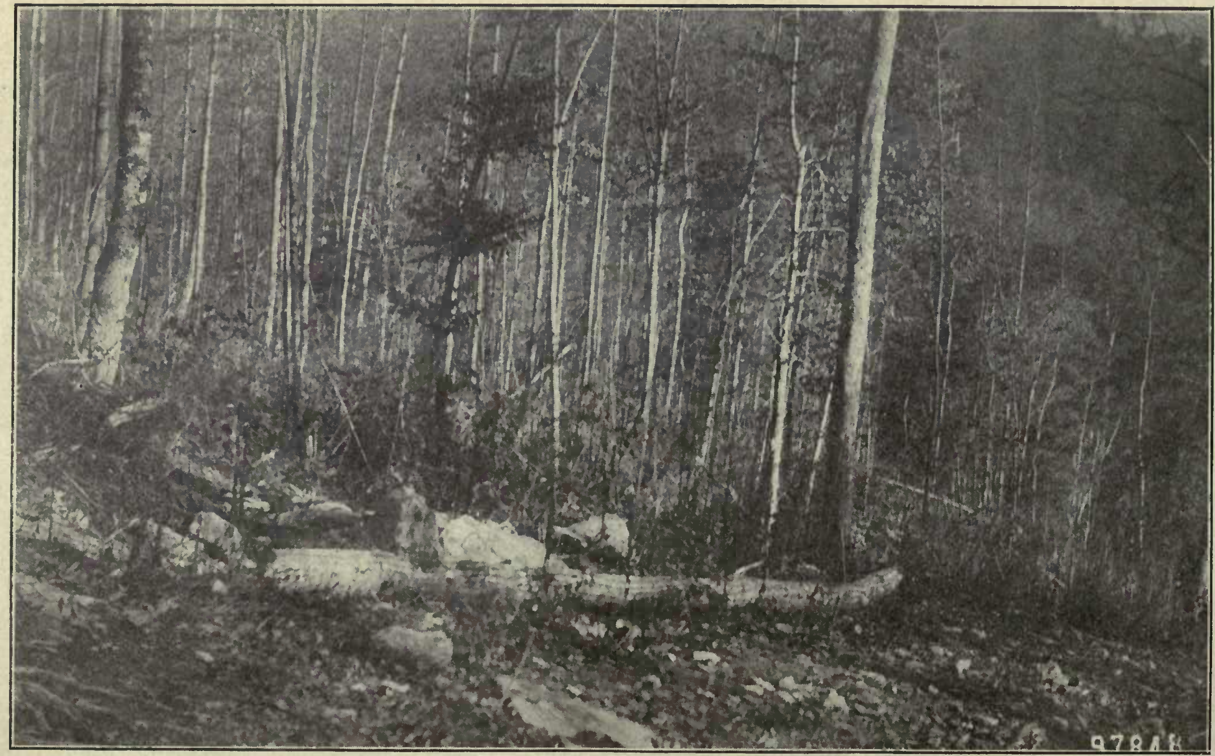
Red cedar is also a common conifer in the various types of this region, chiefly on limestone land.

A local type of some importance in the northern part of the region might be called "short-leaf pine flats." The soil is a dry, loamy sand, sometimes mixed with clay, and the ground cover is either entirely absent or consists of a thin layer of grass, weeds, and leaves. Dense groups of sumach, sassafras, huckleberry, and blackberry form an irregularly scattered underbrush. Short-leaf pine and black oaks, including scarlet and Spanish, and occasionally a willow oak and some scrub pine, are the chief trees. These are associated with a scattering of other hardwoods and an occasional loblolly pine in moister situations. Short-leaf pine predominates and is the most valuable tree. While the pine is sometimes pure, it is common to find pine and hardwoods mixed, either by groups or as single trees.

CUMBERLAND PLATEAU.

The Cumberland Plateau is a high table-land, 5,000 square miles in extent and 2,000 feet in elevation, which lies west of the Valley of East Tennessee and is separated from it by a fairly regular line of precipitous sandstone cliffs. The western boundary, which is also marked by sandstone cliffs, is much more irregular, following a series of projecting headlands inclosing rich coves. The surface of the table-land is cut by numerous ravines and deep valleys, and is especially well dissected toward the north and west. Most of the northern part is drained in a northerly direction by tributaries of the Cumberland. South of Cumberland County the drainage is tributary to the Tennessee River. There are no navigable rivers in the region, but facilities for railroad transportation are fair. The central part is crossed by the Tennessee Central Railroad, while the Cincinnati Southern extends across the plateau north of Harriman, and then runs southwest from this point just beyond and parallel to the eastern escarpment. It is also penetrated by branches of the Nashville, Chattanooga and St. Louis Railway from the south and west. Probably about half of the land is concentrated in large holdings of value chiefly for coal or timber, or for both.

Lumbering and coal mining are the chief industries. Agriculture is of minor importance at present. In addition to saw timber, important forest products are cross-ties, chestnut poles, spokes, handles, extract wood, and tanbark. The largest lumbering oper-



Growth of About Fifteen Years on Old Field on Lower Slope; Chiefly Poplar, with Some Oak—Scott County.

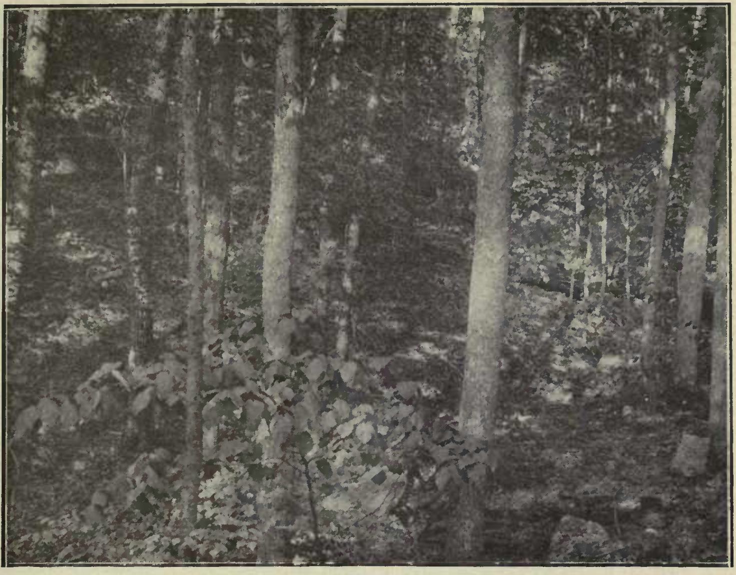


FIG. A.—RIDGE TYPE OF CUMBERLAND PLATEAU; OAKS, HICKORY, AND BLACK GUM—CLAIBORNE COUNTY.

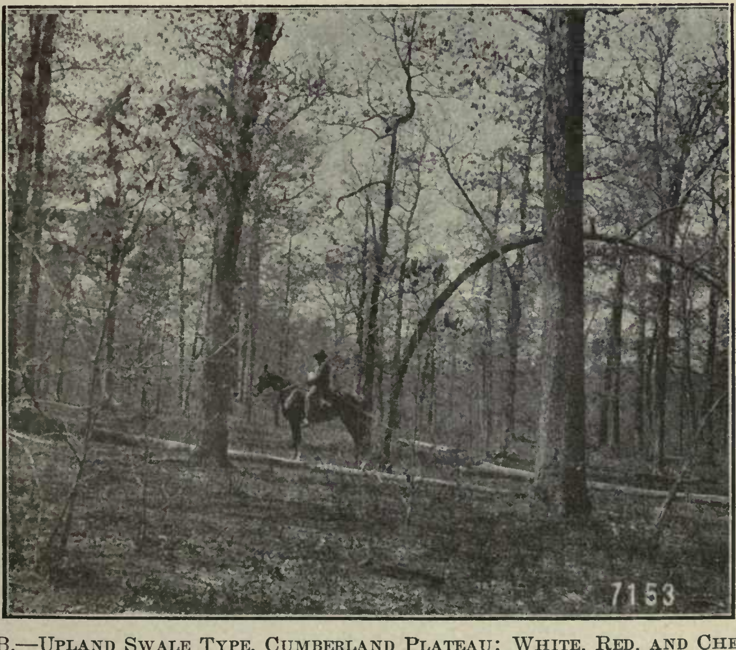


FIG. B.—UPLAND SWALE TYPE, CUMBERLAND PLATEAU; WHITE, RED, AND CHESTNUT OAKS AND MOCKERNUT HICKORY—CLAIBORNE COUNTY.

ations are found in the north and northwest portion of the region, where private logging railroads have been constructed. Small operations, usually conducted with portable mills, are numerous and widespread. Throughout the region are small and scattered tracts of practically virgin timber which have been held for one reason or another. The larger bodies and those containing timber of the best quality are found in the northern part in Pickett, Overton, Fentress, and Scott Counties.

There are four distinct types of forest land in this region—coves, slopes, plateau ridges, and plateau swales. Of these, the cove and slope types are the most important from the commercial standpoint.

The proportion of land in each type varies greatly in different sections of the region. A careful survey of a large and fairly typical tract on the waters of Rocky River showed about one-sixth of the area to be cove and slope land, one-third plateau swales, and one-half plateau ridges. On the other hand, in a well-dissected section farther north nearly a third of the area consisted of cove land, while practically all of the rest was of the slope type.

Coves.—The cove lands consist of the better portions of the valley slopes and hollows well below the level of the plateau. The characteristic soil is a deep, moist loam, rocky or stony, upon which is a layer of humus, often several inches in depth. The underbrush varies in density and usually consists of rhododendron, laurel, red bay, witch hazel, persimmon, dogwood, and viburnum. The characteristic and dominant trees of the type are white oak, yellow poplar, and chestnut. Beech and sugar maple are also very numerous. Among the associated species are hickory, black oak, red oak, chestnut oak, buckeye, red maple, basswood (linn), ash, elm, and an occasional walnut, cucumber, and cherry. Hemlock is also found, sometimes singly, but usually in groups, and sometimes with white pine. The chief difference between this type and the true Appalachian cove type lies in the smaller proportion of hemlock and the larger amount of white oak. Reproduction is fairly good, although shade conditions in the typical older stands favor seedlings of tolerant species, such as sugar maple and, to a less extent, hickory and ash. Oaks, red maple, and yellow poplar come up in the natural openings of the forest. Yellow poplar reproduces best, however, on abandoned fields, where it sometimes forms an almost pure stand.

The characteristic timber of this type is straight, tall, clean, and of excellent quality. Virgin stands yield on the average about 8,000 board feet per acre.

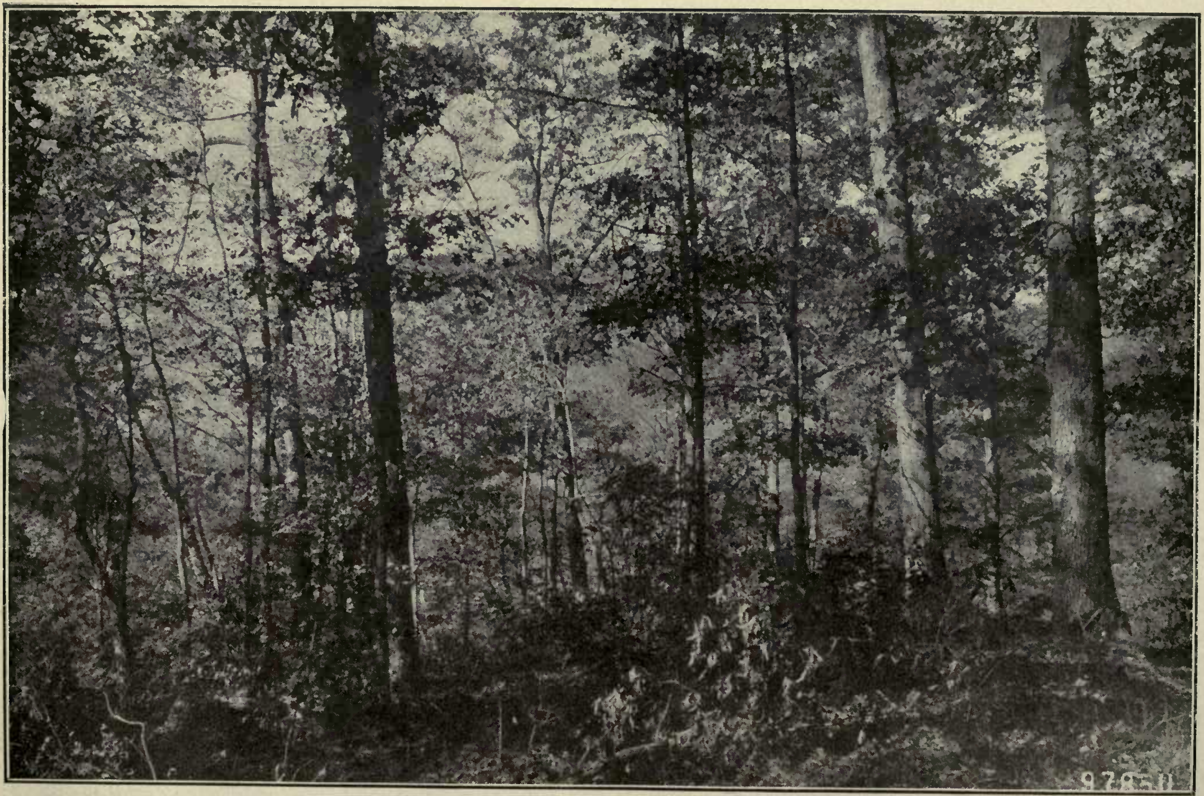
Slopes.—The slope type includes south and upper north slopes, and is intermediate, both in situation and quality, between the cove and plateau types. The characteristic trees are chestnut oak, black, scarlet, and white oaks, and hickory. Usually either chestnut oak or one of the black oaks predominates. Chestnut, black gum, and short-leaf pine are also common, the pine usually in groups. The quality and amount of timber is somewhat inferior to that found in the coves, virgin stands yielding only about 6,000 board feet per acre.

Plateau Swales.—The plateau swales are the lower portions of the table-land, including the flat lands and shallow depressions along drainage lines that lie below the general level of the ridges. The soil is of good depth, especially if the land receives the wash from the slopes, and it is fairly moist because the water does not drain off rapidly. Black, white, Spanish, and scarlet oaks, with a varying proportion of hickory, predominate in this type. Black gum, post and chestnut oaks, chestnut, and short-leaf pine are also sometimes included in the mixture. The swampy bottoms, which are of very limited extent, contain thickets of red maple, black gum, and sweet gum, often with an undergrowth in which large holly trees are conspicuous. The timber does not grow as high as that of the coves and is not so clear and free from defects. The yield per acre of virgin timber averages about 4,000 feet.

Plateau Ridges.—These are the highest and most exposed portions of the table-land, with thin, sandy, unproductive soil. They are covered with a short and stunted growth of inferior hardwoods, such as post, black jack, scarlet, and chestnut oaks, sand hickory, and black gum, with some scrubby chestnut. Scrub pine, and sometimes short-leaf, grow on this land in mixture with the hardwoods or in pure stands. The timber is not only short-boled and limby, but is usually badly injured by insect and fungus enemies, partly owing to the frequency with which fires occur. The stand is open and at best yields only about 2,000 board feet per acre.

HIGHLAND RIM.

The Highland Rim is a high, broad shelf surrounding the Central Basin, with an area of 9,300 square miles and average elevation of 950 feet above sea level. It is a rolling country, with broad valleys and rounded hills. The underlying rock is chiefly limestone. There is great variety in the quality of the soil, perhaps the poorest being found on the cherty formations that immediately surround



Slope Type of Cumberland Plateau; Chiefly White, Black, and Spanish Oaks—Scott County.

the Central Basin. The drainage system is well developed, and there is very little swamp land. The greater part of the land drains south and west toward the Tennessee River, although a section on the north is included in the basin of the Cumberland.

In addition to the Cumberland and Tennessee, which are both navigable rivers, there is a good system of railroad transportation, so that few places are more than 12 miles from shipping points. The most inaccessible portion is found in Wayne County, in the southwest corner of the region. By far the larger part of the land is in farm holdings of moderate size.

The chief industry is agriculture, although lumbering and mining for phosphate and iron are also of local importance. Lumber, cross-ties, spokes, and handles are the most important forest products. Most of the lumbering operations are on a small scale, since, with the exception of a few of the more inaccessible counties, the merchantable timber is distributed in a very scattered manner in farm wood lots and small tracts. There is very little virgin timber left, the principal bodies lying about halfway between the railroad and the Tennessee River, in Wayne, Lawrence, and Perry Counties, and in the northeast corner of the region, in Pickett and Overton Counties.

There is a great diversity in the character of the forests of this region, but they may be roughly grouped into slope and ridge types. A cove type, very similar to that described for the Cumberlands, is also found in this region at the base of the Cumberland Plateau, along the margin of the Central Basin and in the southwestern counties along the Tennessee River. There is more or less land which was once cleared, but which proved either too poor or too steep for farming and is now reverting to forest or has already done so. The stands are uneven-aged except in the neighborhood of old iron furnaces, which were once very common in the western part of the region. Here the forest was cut clean for charcoal, and even-aged stands have resulted, covering extensive areas.

Slopes.—The soil of the slopes, which, as a rule, are moderately steep, is somewhat better than that of the ridges, but most of the agricultural soils have been cleared and put under cultivation. The type is characterized by a mixture in which the oaks predominate, especially black, red, Spanish, and white oaks. Hickory is also a very constant constituent of the stand. A great many other hardwoods are included, the most important of which are chestnut, yellow poplar, black gum, and ash. Beech is also found on the lower slopes, and sycamore along the streams.

Ridges.—The ridges are either narrow and rounded or broad and flat, but are characterized by a thin, sandy, unproductive soil, often strewn with chert fragments. Scarlet, black jack, and post oaks, and hickory are the common ridge trees, constituting a type similar to the Cumberland Plateau ridges, but on the whole of somewhat better quality. In the southern part of the region, especially in Wayne and Perry Counties, there are occasional belts of shortleaf pine, either pure or associated with scattering post and black jack oaks. The quality of the pine is much better than that of the hardwoods of this type.

CENTRAL BASIN.

The Central Basin, an oval depression 5,400 square miles in area, about 400 feet below the level of the surrounding Rim, is, on the whole, a gently rolling region underlaid by limestone and possessing very fertile soils. The outer portions of the region are somewhat rougher. The drainage is toward the north, south, and west through the Cumberland, Duck, and Elk Rivers, the two latter being tributaries of the Tennessee. Numerous railroads radiate from Nashville, affording, together with the Cumberland River, good means of transportation. The principal wagon roads are macadamized. With the exception of a few large estates, the land is held in small farms.

The chief industry of the region is agriculture. A few select saw logs are shipped from various points, principally to the veneer factories; while small mills, often run by threshing-machine engines, saw a little lumber for local use. The red-cedar industry centers at Murfreesboro, where there is a pencil-wood factory which depends principally upon this region for its supply. This species also supplies the market with a great many fence posts and small poles.

The forest is largely confined to small, ornamental groves and to belts or patches of timber on broken land along the creeks and on the poorer hillsides and ridges. The groves are, as a rule, located near or about the farmhouses on good agricultural land. The ground is usually covered with blue grass, with no tree reproduction. These remnants of the original forest are preserved for their natural beauty, for shade about the house, or to protect the cattle from the sun in the heat of summer. Stands of this type are usually composed of mature or overmature trees, which are often widespreading and limby. Many of these old trees, especially the elm,

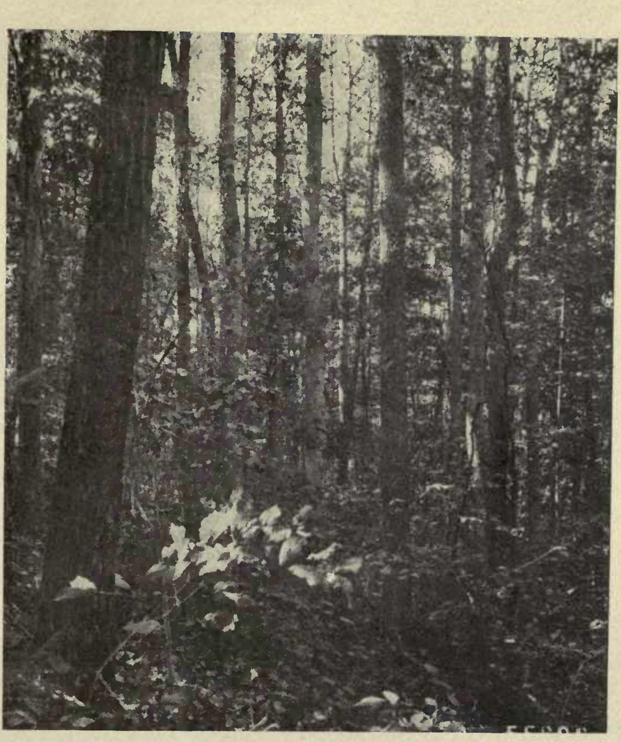


FIG. A.—SLOPE TYPE OF THE HIGHLAND RIM; OAK, POPLAR, AND CHERRY—STEWART COUNTY.

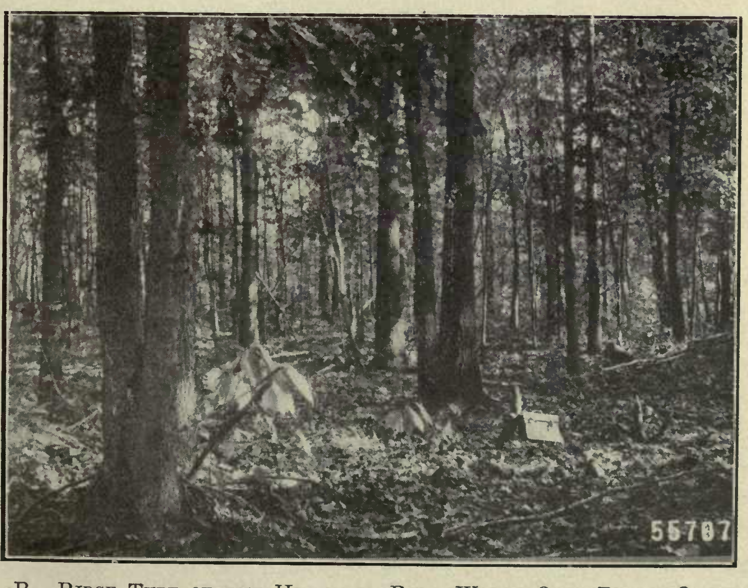


FIG. B.—RIDGE TYPE OF THE HIGHLAND RIM; WHITE OAK, BLACK OAK, AND HICKORY—STEWART COUNTY.

are dying out, sometimes as a result of changes in drainage conditions. The most common species are white, cow, chinquapin, and bur oak, hard maple, ash, walnut, sycamore, elm, buckeye, and butternut.

The scattering bodies of timber on broken land near creeks are composed of about the same species that are included in the pastured groves. On the hills and ridges, however, many other hardwoods are represented, including chestnut and other oaks, beech, sugar maple, and hickory. Red cedar is sometimes found in mixture with these hardwoods and sometimes in pure groups. It is especially characteristic of thin-soiled, stony, limestone hillsides.

The abandoned fields show a great variety of tree growth. Sassafras, persimmon, hickory, patches of black locust, groups of poplar on moister situations, and red cedar in dense thickets, or scattered singly, may frequently be met with all on the same farm.

WEST TENNESSEE PLATEAU AND BOTTOM LANDS.

The country between the Tennessee and Missisippi Rivers may be considered as one forest region, although it includes two physiographic divisions and part of a third. The Plateau and Slope lands comprise an area of about 8,850 square miles, and the bottom lands of the Tennessee and Mississippi Rivers nearly 1,500 square miles. The region is mostly under 600 feet in elevation, the uplands rising from 200 to 400 feet above the stream bottoms. The greater part of the region is a low, rolling upland, with a short slope on the Tennessee side, and a long, gentle, westward slope to the bluffs that border the Mississippi bottom lands. The underlying rock seldom outcrops and is covered by a deep mantle of unconsolidated deposits of clay, loam, and sand. The soil of the bottoms is alluvial in origin and of great fertility, although not always available for agriculture because of insufficient drainage and danger of overflow. The upland soils vary considerably in quality, the more fertile loams covering the western half of the plateau. They are, as a rule, compact and wash badly even on very moderate slopes. In addition to the two navigable rivers that bound the region, a network of railroads affords good transportation facilities. The farms are mostly small, averaging about 100 acres, while the large holdings are practically confined to portions of the Mississippi bottom lands.

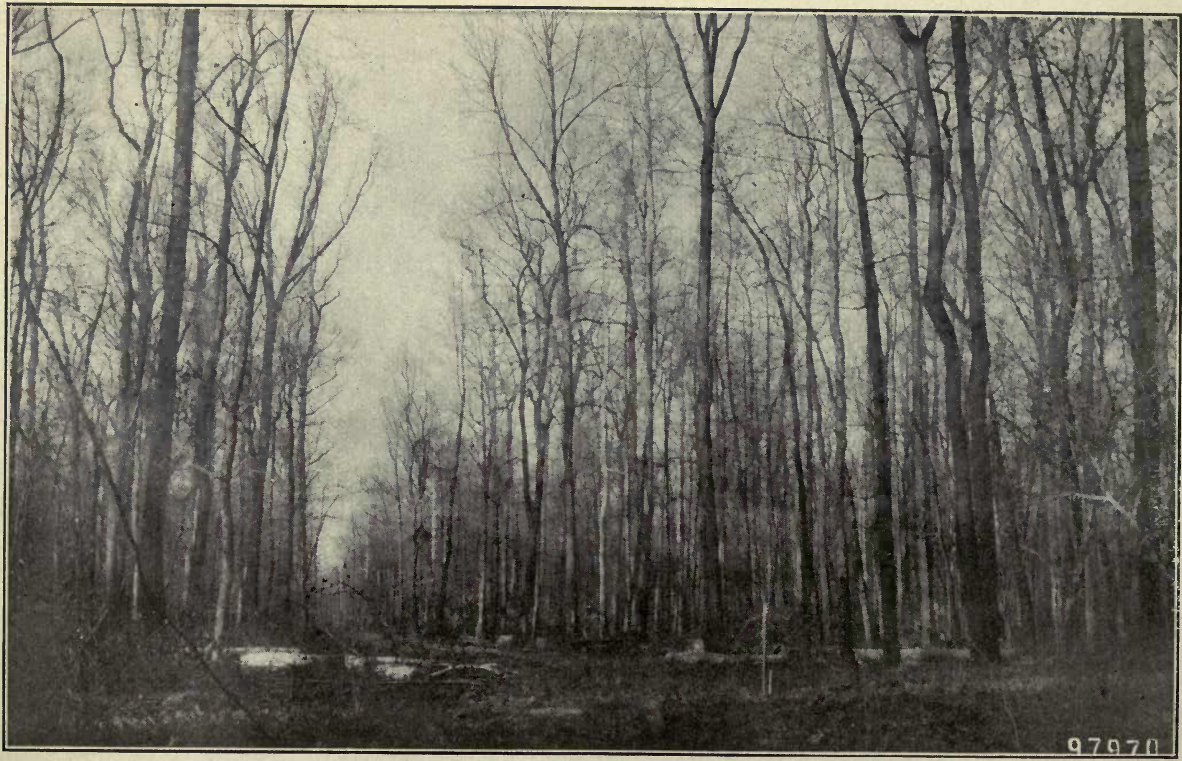
This is primarily an agricultural country, with cotton as the chief money crop. Lumbering on a large scale is carried on only in the bottom lands of the Mississippi. The principal forest products are lumber, cross-ties, box veneers, cooperage stock, and spokes. The greater part of the timber cut comes from the bottom lands.

Uplands.—The upland forests are of two types—one in which post oak is the characteristic tree, and another in which the better oaks predominate. The post oak type is found on the higher ridges and upper slopes of the hilly sections and on sandy, sterile flats. It is particularly characteristic of the soil type described by the United States Soil Survey as Lexington sandy loam. With post oak are most commonly associated black jack, scarlet and Spanish oaks, and pignut hickory. The trees are small-sized and short-boled, averaging from 6 to 14 inches in diameter and yielding little timber of value. In the southwestern counties of Hardin and McNairy the type is occasionally interspersed with stands of short-leaf pine.

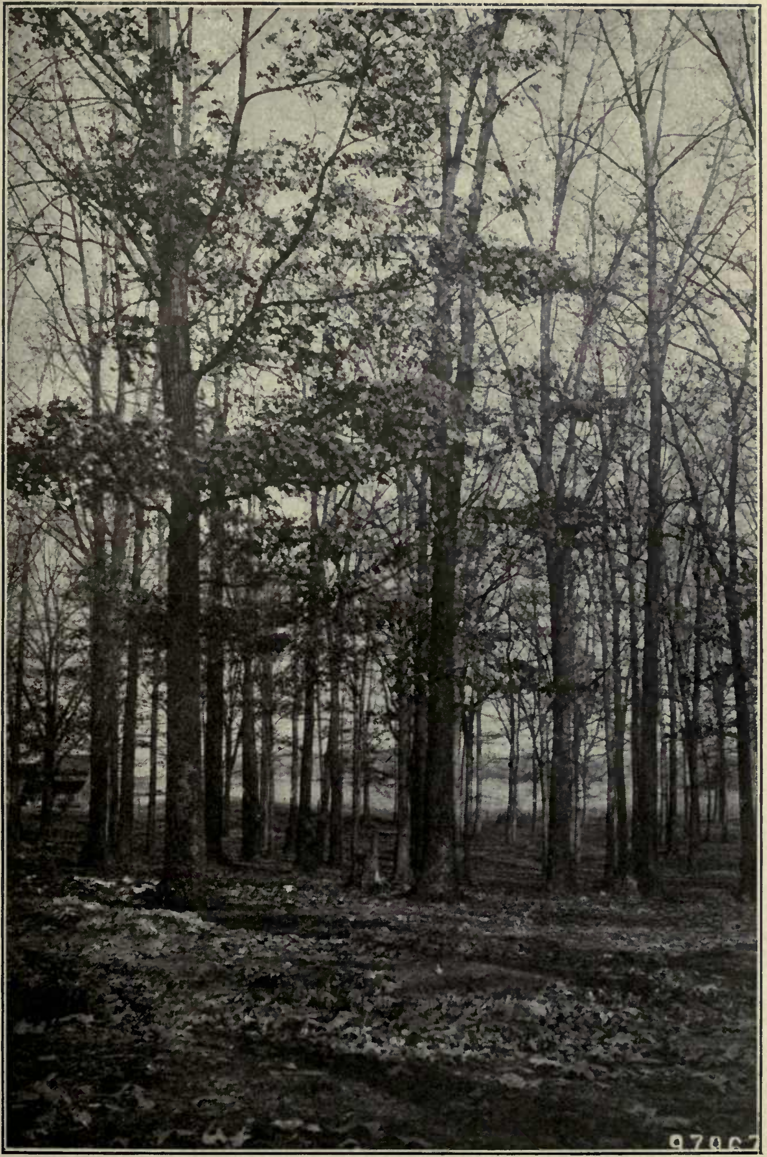
On the lower ridges and slopes and on gently rolling lands of the soil type described as Memphis silt loam a better group of hardwoods prevails. The principal species are white, Spanish, and black oaks, pignut and mockernut hickories, and scattered chestnuts. Along drainage lines, tulip poplar, sweet gum, beech, and sycamore are also found. The stands are uneven-aged, and the trees generally run from 8 to 16 inches in diameter. This type is naturally productive, but has suffered from unsystematic cutting and general neglect.

Bottom Lands.—The bottom-land forests reach their greatest extent and importance on the broad flood plain of the Mississippi, but also occur on the various rivers and creeks that drain the uplands. The virgin stands are dense, with tall, clear trees which form an unbroken canopy of foliage. The typical tree is red gum, which makes up about 50 per cent of the forest. Oak, ash, cottonwood, hickory, cypress, elm, sycamore, soft maple, and tupelo gum are the common associates. The black-oak group is represented by red, swamp Spanish, and some few pin and willow oaks. Cow oak is the chief bottom-land white oak. Among the hickories are included the bottom shellbark, shagbark, and mockernut. Cottonwood is an important constituent of the forest on the Mississippi bottoms, especially on low, sandy land of recent origin; while on the bottoms of the smaller streams the oaks are of greater importance. Some beech is found on low ridges and is one of the few bottom-land timbers for which there is almost no market. There is usually a scattered underwood of hawthorn, holly, dogwood, and young growth of gum, hickory, hackberry, and other trees.

Few virgin forests of this type remain, the most extensive of



RIGHT OF WAY CUT FOR LOGGING RAILROAD THROUGH MISSISSIPPI BOTTOM-LAND FOREST; CHIEFLY GUM, SYCAMORE, AND ELM—DYER COUNTY.



Pastured Wood Lot, Upland Type of West Tennessee Plateau; Spanish Black, and White Oaks—Hardeman County.

which are on the Mississippi bottoms in the northwestern part of the region. Such forests have an average stand of from 10,000 to 12,000 board feet per acre. The gum, oak, and cottonwood timber is of excellent quality; but the cypress is very defective, running at least 50 per cent "pecky." Growth is very rapid on cut-over lands, and the fire damage is small on account of the wet character of the situation. This is not, however, a permanent type, since most of the land will eventually be reclaimed for agricultural purposes.

FOREST PROBLEMS.

UNAKA RANGE AND CUMBERLAND PLATEAU.

While the forest types in the Unaka Range, the more mountainous ridges of the Valley of East Tennessee, and the Cumberland Plateau differ somewhat, the problems of forest management are in general very similar. In contrast to the rest of the State, they are essentially timber-exporting regions and should always remain so. Moreover, they constitute an important part of what is known as the southern Appalachian region, which is bound to be the chief source of the future hardwood supply of the United States. The other regions in the United States from which hardwood lumber is obtained are nearly all agricultural in character and must eventually be used primarily for that purpose. While the soil of the Unaka Range is in many cases fertile, the mountain sides are so steep that farming is not practicable and timber is bound to be the chief crop. The Cumberlands, on the other hand, have certain agricultural possibilities. The level plateau land may eventually be farmed with profit by the liberal use of fertilizers and other intensive methods, when market conditions warrant the expense. Nevertheless, there probably will always be much more absolute forest land than is necessary to supply the local demand for timber and wood.

The fact that the Cumberland and Tennessee Rivers head in these regions also gives them peculiar importance. The forests of the mountain slopes should be maintained to check the run-off and to regulate stream flow. Their preservation is essential for the successful utilization of water power and effectual artificial storage. The protective function of the forest cover is of especial importance in the Unaka Range because of the great height of the slopes. These problems are discussed in detail in the "Report of the Secretary of Agriculture on the Southern Appalachian and White Mountain Watersheds,"* and need not be enlarged upon here.

The small proportion of virgin timber which remains is very inaccessible and must be logged at considerable expense. The private companies who own this timber regard it as necessary to cut all the trees that can be handled at a profit, in order to pay the cost of constructing the logging railroad and other fixed expenses. Accordingly, they do not intend to cut conservatively nor to protect the young growth for a second crop.

The greater part of the land is already heavily cut over. Many small tracts have also been cleared for farming, worn out in a few years, and then abandoned. In the more inaccessible sections the usual practice is to kill the large trees by girdling and to leave them standing. On these abandoned farm lands even-aged stands have sometimes started as a result of seeding from neighboring trees.

The growth of woody vegetation is so vigorous that cut-over lands which have not been plowed seldom become bare and totally unprotected against erosion, even in spite of fire and other adverse influences. The chief danger from washing is along old skid roads which follow drainage lines, and thus give a foothold for the destructive action of water. In a few cases this danger has been guarded against by piling slash in the skid roads after the last logs have been hauled down, in order to check washing until vegetation has had a chance to establish itself. Little is done to prevent fires on cut-over land, except when necessary to protect fences and virgin timber. The effect of the repeated burning is to prevent the reëstablishment of a valuable forest growth. An inferior growth of sprouts comes up from the burned stumps, and the development of hardy, but valueless, shrubs is encouraged. The most valuable trees, such as yellow poplar, chestnut, and white pine, are the most sensitive to fire injury. Such a growth as persists in spite of repeated burning, while it often is sufficient to prevent the soil from washing off of the steep slopes, does not have the effect in regulating run-off that a better forest growth possesses. There is not as good shade, the spongy layers of humus and leaf litter are destroyed, and the capacity of the soil to absorb moisture is reduced.

As soon as the fire risk is reduced to a minimum, other measures can be taken to improve the forests and make timber growing profitable. The composition and rate of growth can be improved by thinning out the inferior species and poorer individuals from

---

* United States Senate Document 91.

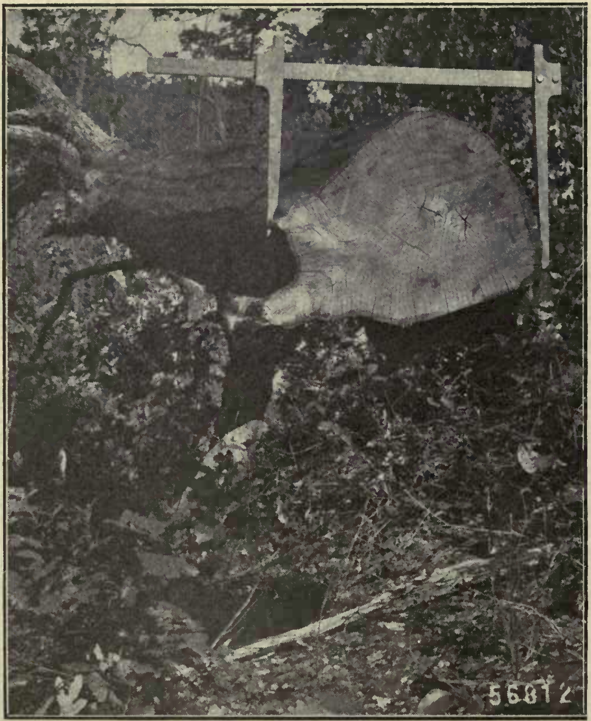


FIG. A.—A ROUGH, LIMBY CHESTNUT OAK TOPPED AT 23 INCHES, WASTING TWO STANDARD TIES—SULLIVAN COUNTY.

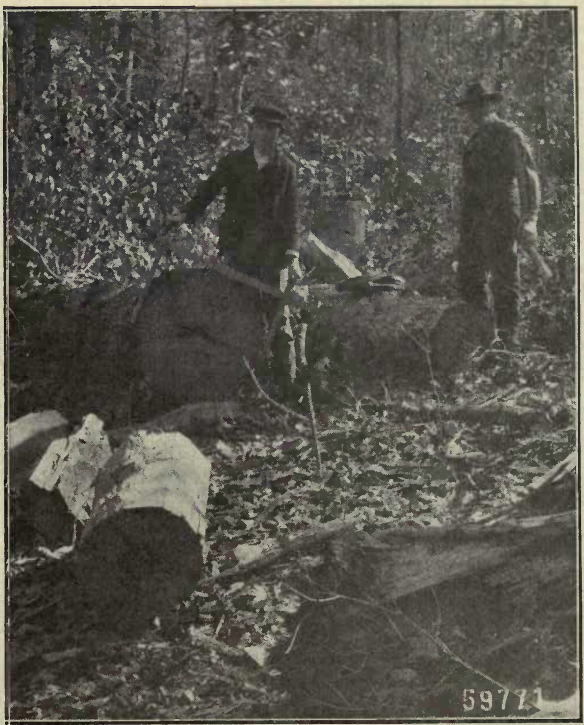


FIG. B.—WASTE IN CUTTING STAVE BOLTS; TOP, 28.3 INCHES IN DIAMETER, LEFT ON ACCOUNT OF KNOTS AND WATER SOAK—GILES COUNTY.

tary of Agriculture on the Southern Appalachian and White Mountain Watersheds,"* and need not be enlarged upon here.

The small proportion of virgin timber which remains is very inaccessible and must be logged at considerable expense. The private companies who own this timber regard it as necessary to cut all the trees that can be handled at a profit, in order to pay the cost of constructing the logging railroad and other fixed expenses. Accordingly, they do not intend to cut conservatively nor to protect the young growth for a second crop.

The greater part of the land is already heavily cut over. Many small tracts have also been cleared for farming, worn out in a few years, and then abandoned. In the more inaccessible sections the usual practice is to kill the large trees by girdling and to leave them standing. On these abandoned farm lands even-aged stands have sometimes started as a result of seeding from neighboring trees.

The growth of woody vegetation is so vigorous that cut-over lands which have not been plowed seldom become bare and totally unprotected against erosion, even in spite of fire and other adverse influences. The chief danger from washing is along old skid roads which follow drainage lines, and thus give a foothold for the destructive action of water. In a few cases this danger has been guarded against by piling slash in the skid roads after the last logs have been hauled down, in order to check washing until vegetation has had a chance to establish itself. Little is done to prevent fires on cut-over land, except when necessary to protect fences and virgin timber. The effect of the repeated burning is to prevent the reëstablishment of a valuable forest growth. An inferior growth of sprouts comes up from the burned stumps, and the development of hardy, but valueless, shrubs is encouraged. The most valuable trees, such as yellow poplar, chestnut, and white pine, are the most sensitive to fire injury. Such a growth as persists in spite of repeated burning, while it often is sufficient to prevent the soil from washing off of the steep slopes, does not have the effect in regulating run-off that a better forest growth possesses. There is not as good shade, the spongy layers of humus and leaf litter are destroyed, and the capacity of the soil to absorb moisture is reduced.

As soon as the fire risk is reduced to a minimum, other measures can be taken to improve the forests and make timber growing profitable. The composition and rate of growth can be improved by thinning out the inferior species and poorer individuals from

---

* United States Senate Document 91.

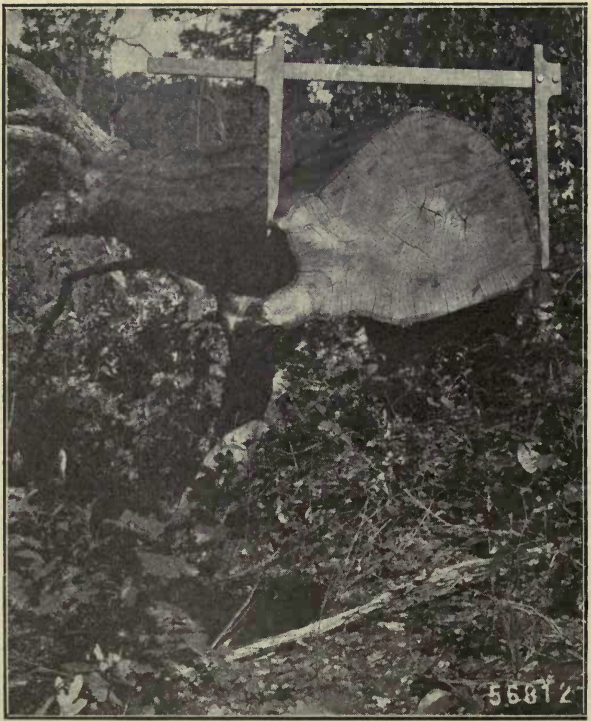


Fig. A.—A Rough, Limby Chestnut Oak Topped at 23 Inches, Wasting Two Standard Ties—Sullivan County.

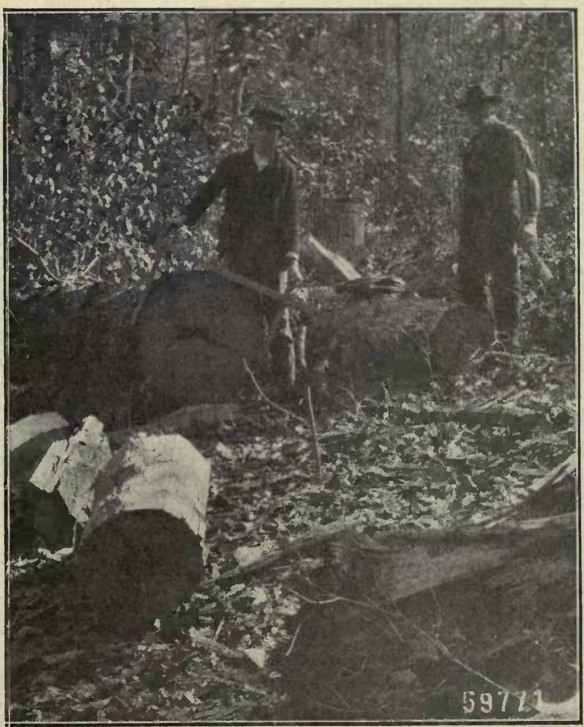


Fig. B.—Waste in Cutting Stave Bolts; Top, 28.3 Inches in Diameter, Left on Account of Knots and Water Soak—Giles County.

crowded stands. In making final cuttings, certain principles can be observed that will insure a second crop from the young trees in the shortest possible time, as well as reproduction from seed and sprouts. In these regions the chief object of management will be the production of saw timber, although many other products will also be obtained. For this purpose yellow poplar and chestnut are the most promising in the Unaka Range, while white oak may be included with these in the Cumberlands. Short-leaf pine will also be a very valuable tree on the driest soils of the Cumberland Plateau lands where valuable hardwoods will not thrive. Hickory is likewise important, especially in the Cumberlands. While the best hickory timber grows on upper north slopes in mixture with oak, the younger growth is of fair quality in almost all situations. Reproduction is good and growth rapid enough to make it well adapted to management and an important tree for the future. Excellent fuel can be obtained from the smaller trees cut out in thinning, while the larger timber is of especial value in the manufacture of vehicles.

A large amount of woodland in the Cumberlands is underlaid by workable coal. This land should be managed for the production of mine timbers, in order to render the mines independent of the general market for their supply. At present there is very little method in the selection of timber for use in the mines, this usually being left to the contractor. Consequently, the most convenient trees are cut without regard to the effect on the forest. Usually the slopes nearest the mines are devastated, while more remote bodies of timber belonging to the same property are deteriorating from decay and overcrowding. Whether the land is owned by the mining company or merely leased, it would be profitable to all concerned to institute improved methods of cutting so as to conserve the supply and improve the condition of the forest. Owners of coal lands should see to it that provisions to this end are inserted in mining leases. A few of the more progressive companies have already taken steps in the right direction. The fact that small-sized trees of all kinds can be utilized gives an exceptionally good opportunity to thin out the forest in such a way as to increase the growth and improve the quality of the timber produced. Just how this can best be accomplished would be an important subject for investigation by a State Forester.

One of the most important problems before the State is the affording of adequate fire protection to forest land, and this problem is especially vital in these timbered regions. Legislative and other means toward this end will be discussed in another part of this report. The State should also inaugurate studies of the rate of growth and silvicultural requirements under local conditions of the more important species, in order to show the probable results that can be obtained in growing timber and the best methods to use. An investigation of short-leaf pine and the conditions under which it reproduces would be of great practical value, especially in the Cumberlands. A study of second-growth chestnut and yellow poplar in Tennessee has already been started by the State Geologist in coöperation with the Forest Service for the purpose of determining the most practicable methods of management. A study of the management of coal lands for mine timbers, to find the methods that are most suitable and the probable yield in each type, is greatly needed in the Cumberland Plateau.

VALLEY OF EAST TENNESSEE AND HIGHLAND RIM.

While these regions are separated by the Cumberland Plateau, the character and distribution of the forests and the broad problems of forest management are similar, if the more mountainous ridges of the Valley of East Tennessee be excepted. Both contain a considerable proportion of absolute forest land, possibly one-fourth of the total area. Forestry will, however, always be subordinate to farming. The forest is broken in distribution and owned mainly by farmers. It is largely depleted of valuable timber, and its productive capacity has deteriorated because of fires, indiscriminate grazing, and repeated culling of the best trees.

A considerable proportion of the timber produced in the future will be used directly upon the farm. There is also a good general market for nearly all classes of forest products in the numerous towns and cities. Management can, therefore, be on a rather intensive basis, and the farmer can well afford to use his spare time in keeping his woodland in the best possible condition. He can usually find ways of using on his own place the material that he thins out, even if no other market can be found for it. Unfortunately, the improvement of farm wood lots ordinarily receives little consideration. Trees are cut because they are handy and suit the purpose, even if it would be much more profitable in the long run to leave them and use instead inferior or overmature trees that might be a little more difficult to get at or work up. It is also a common mistake to try to combine timber and grass production, with poor results in both directions. Grass will grow but very sparsely under trees which are close enough together to produce good timber, so that pasture land should be cleared except for a few scattered, windfirm, shade trees. On the other hand, woodlands should be kept fairly dense, and no attempt should be made to graze them heavily. It is especially necessary to keep out all live stock during a period when it is desired to establish a young growth of trees. Hogs are particularly destructive in such a period, since they devour the seed of nut-bearing species and root up many young seedlings.

All of these questions, however, require further investigation under the special conditions that prevail in different sections. Also a great deal of educational work is needed in order to acquaint the people with the fundamental principles of forest management. More accurate information should be obtained in regard to the growth and requirements of the important species, such as chestnut, yellow poplar, Spanish oak, black oak, hickory, and short-leaf pine. Methods of thinning and otherwise improving the even-aged stands on furnace lands in the western part of the Highland Rim should also be studied.

CENTRAL BASIN.

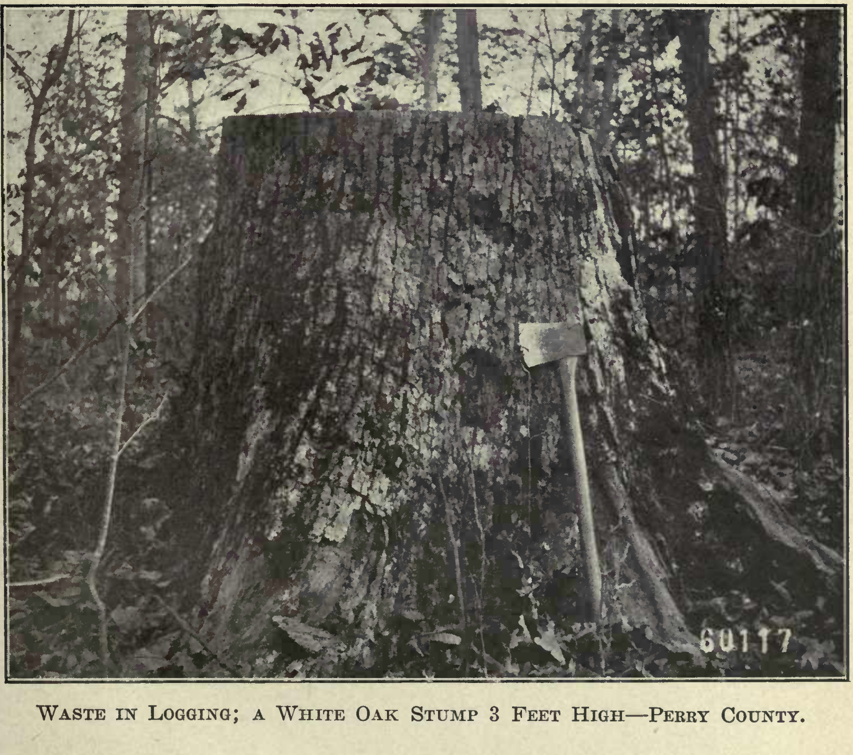
Although the Central Basin does not contain nearly enough land which can profitably be devoted to raising timber to supply its own needs, it nevertheless presents certain problems in forest management that are of local importance. Many of the small pasture and ornamental groves are dying out because of the old age of the trees, or changes in drainage, or other conditions. The usual sod of blue grass, the trampling of stock, and close pasturage, prevent natural restocking with young trees. This might be secured by breaking up the sod and excluding stock. Such treatment is not usually advisable, however, since satisfactory results can be obtained by planting in small groups and leaving the greater part of the grass undisturbed. Of course, all seedlings must be fenced for protection until they are large enough so that stock will not injure them. In regard to the present stand, the cutting must be made with a view to keeping as many of the older trees as long as possible. The strengthening of decrepit old trees by mechanical means, as well as pruning, may often be justified because of their ornamental value. Such measures, however, belong to the field of arboriculture rather than of forestry.

The very limited area that can be used as wood lots should be made to yield as many posts and other farm timbers as possible. The principal problems connected with wood-lot management are similar to those that have already been mentioned for the Valley of East Tennessee and the Highland Rim. In many cases it may be necessary to plant young trees in order to secure a full growing stock. The natural locust groves may often be made more productive by judicious thinning. There should be a good profit in growing red cedar on stony hill sides that are not of much value for other purposes, since fence posts can probably be grown in open stands in twenty-five years. Information on methods of management of red cedar for pencil wood may be obtained from Circular 102 of the United States Forest Service.

WEST TENNESSEE PLATEAU AND BOTTOM LANDS.

The management of farm wood lots is the chief problem of the uplands here, as in the other agricultural districts. Also the problem of the best use of land presents itself in another form. In this case woodland is being unwisely cleared by negro farmers in order to secure fresh land for cotton. Since the soil is compact and there is a strong tendency to form gullies even on moderate slopes, considerable land which should be retained in forest is ruined in this way.

As the bottom lands are drained and protected, the forests there will eventually be reduced to small farm wood lots in the lowest and poorest situations. Since this drainage work goes on slowly, it will be possible on many tracts to obtain one or several crops of timber before it is completed, especially as most of the bottom-land trees are very rapid growers. In order to obtain the greatest increment in both volume and quality on such forest lands, it is necessary in the original cutting to use a higher diameter limit than if no future cutting were in view. Also it is often possible in the case of dense stands of moderate-sized trees to thin them out in the first cutting, thereby stimulating greatly the growth of those that remain and procuring large timber for the next cutting. Cottonwood is especially adapted to such treatment. It is also wise to remove old, decadent trees that take up a great deal of room and hinder the development of young poles and saplings, even if there is no profit in handling them. One company has adopted this policy of conservative cutting, using a diameter limit of 24 inches on the stump for gum, but such far-sighted methods are not general. Of course,



WASTE IN LOGGING; A WHITE OAK STUMP 3 FEET HIGH—PERRY COUNTY.

there would be no inducement for a timber operator, owning only the stumpage rights, to adopt such a policy unless some special arrangement were made for this by the landowner.

FOREST POLICY FOR THE STATE.

NECESSITY FOR ACTION.

It was not possible with the time and funds available for the preliminary study upon which this report is based to estimate the amount of standing timber or determine how soon a scarcity of the supply is likely to be felt. However, it is already becoming difficult for consumers of high-grade lumber to get enough raw material for their uses. All indications point to a continued supplanting of higher grade timber, with lower grades as far as this is possible, and to a period of scarcity and restricted production in the not far distant future. Eventually the annual cut will have to adjust itself to the annual growth of timber on the forest lands of the State.

The exhaustion of the virgin timber is not in itself a disadvantage. It is even necessary that mature and decadent timber be cut out to prevent loss and to allow younger trees room for development. The great evil lies in the fact that little or no attention is paid to securing and fostering a valuable second growth. There is a great deal of land in the rougher parts of Tennessee that will yield little or nothing in any other crop than forest trees. Yet in the face of the growing scarcity of timber, these lands are being allowed to become unproductive through neglect. If timber lands are to remain in a productive state, they must be treated intelligently. No one expects to grow any other crop without attention, and yet no other crop matures so slowly as the forest crop or requires so long a time for the rectifying of mistakes in management.

The forest land of Tennessee is practically all held by private individuals, and by far the greater part will continue to be so held. If forestry is to be practiced, it must, therefore, be by these private owners. Most of them will do little or nothing along this line unless the State shows them the need and advantage and assists them in using proper methods. In addition, the State should help in giving the landowners protection from fire. There is now a fire law on the statute books which provides penalties for setting forest fires carelessly or willfully, but it lacks an appropriation to make it effective.

In this connection it should be remembered that the Appalachian

Bill which has recently become a law appropriates the sum of $200,000 from the Federal Treasury to enable the Secretary of Agriculture to coöperate with the States, when requested to do so, in organizing and maintaining a system of fire protection on private or State forest lands situated upon the watersheds of navigable rivers. The amount expended in any State cannot exceed the amount appropriated by that State for the same purpose in the same fiscal year. No agreement will be made, however, with any State that has not provided by law for a system of fire protection. In order, therefore, that Tennessee may take advantage of this provision and obtain a share of the appropriation, the State should undertake at once the organization and support of such protective system.

In addition to mere legislation, an educational campaign to show the damage that results from surface fires in woodland is greatly needed and will do much to protect the forests from this danger. It is now recognized by many States that it is to their advantage to promote better methods of forestry just as they are encouraging improvement in agriculture. Sixteen States employ one or more trained foresters in such work, and some of these have also State forest reserves.

The need of educating the owners to increase the productiveness of their woodland is especially important in Tennessee. It is estimated that about 35 per cent of the total area of the State, or 9,300,000 acres, is in woodland. The average annual growth per acre of forest throughout the State is probably not over 100 board feet. Through the application of forestry this should be more than doubled. If, however, it were increased by only 10 board feet, this would mean that the annual timber production of the State would be greater by 93,000,000 board feet. At the low rate of $15 per thousand, this is equivalent to an increased annual income from timber products of $1,395,000, to be distributed among the landowners and those who furnish the labor and materials for marketing these products. Such a gain might be very easily obtained on second-growth lands by giving them a little attention and protection; and as soon as better methods become general, the increase should be much greater. Since culled lands in which old growth still predominates has practically no annual increment, their productiveness can be increased even more by the introduction of proper forest management. The State could well afford to invest an annual appropriation of $20,000 or $30,000 in order to increase the annual income from forest products by over a million dollars.

PROPOSED LEGISLATION.

The legislation in regard to forestry now on the statute books is of a very scattered nature. In addition to the fire law, it consists chiefly in giving investigative functions to three different departments—the State Geological Survey, the Department of Game, Fish, and Forestry, and the Commissioner of Agriculture. It is time to consider what legislation is needed in order to unify and round out a consistent and complete forest law. It is believed that forestry education and forest fire protection are of sufficient importance to warrant the creation of a new department or State Board of Forestry. Accordingly, a plan of legislation is outlined upon this basis. In case it does not seem practicable to adopt this policy, it would be of great advantage to make a special appropriation for the continuation of forest investigations under the direction of the State Geological Survey, either independently or in coöperation with the Federal Forest Service.

The proposed Board of Forestry should be so constituted that it will be free from politics and fitted to take charge of scientific and educational work. Therefore, it is suggested that the board consist of the Governor, the State Commissioner of Agriculture, State Geologist, State Game Warden, Director of the Tennessee Agricultural Experiment Station, and two timber land owners, to be appointed by the Governor, one of whom shall be a manufacturing lumberman. The members should serve without compensation except for necessary expenses.

This board should direct the promotion of the forest interests of the State, and should make a biennial report to the Legislature showing the nature and extent of the work accomplished. It should employ a State Forester, who should be a graduate of a reputable forest school, and a man of experience and ability in his profession. His duties should include (1) the organization of a fire protective force and the administration of the fire laws; (2) the administration of State forests for demonstration and experimental purposes; (3) educational work, such as lecturing on forestry and related subjects before farmers' institutes and other public meetings, and the publication of bulletins; and (4) scientific investigations with a view to increasing the knowledge of the forest resources of the State and to finding out the methods of forest management best suited to local conditions in different sections.

(1) The forestry law of 1907 provides for a system of fire protection under the office of the State Game Warden, giving the

County, Special, and Deputy Game Wardens the duties of forest fire wardens. They are authorized to take charge of fire fighting, to summon assistance, to inspect railroad rights of way, and to arrest, without warrant, offenders against the fire laws. The law has failed in effectiveness because no provision was made for funds to pay the expenses of fire fighting. Also no arrangement was made for posting warning notices; and, therefore, the provisions of the law are not generally known. It is believed that better results would be obtained by not trying to burden the game wardens with this aditional work, which has little relation to their regular duties, and for which they may or may not be fitted. Therefore it is recommended that the State Forester be made State Fire Warden, and that he be empowered to request the Board of Supervisors of each county to appoint, with his approval, a county fire warden, or to appoint one himself should the County Board fail to take action. The county wardens should be subject to removal by the State Forester. The powers and duties conferred upon the game wardens by the law of 1907 should be transferred, with some modifications and additions, to the fire wardens thus provided for, who should likewise be given the powers of sheriffs in enforcing the forest laws of the State. The county wardens should be required to report each fire to the State Forester on suitable forms, to post warning notices, and to patrol in dangerous seasons if directed to do so by the State Forester. If the State Forester deems it advisable, deputy wardens should be appointed by the county warden, with the approval of the State Forester, to work under his direction, with the same powers and duties. The State Forester should also have authority to appoint special wardens, to serve voluntarily without pay, or with compensation from private owners. This would enable suitable employees of parties interested in fire protection to secure the powers of wardens and to coöperate in fire protection without expense to the State or county.

It should further be provided that whenever the State Forester becomes convinced that a dangerously dry time exists, and that it is imprudent to set fire on any land, he shall cause a notice to this effect to be posted in three public places in each county concerned, and that any person setting a fire upon any land in that county after the posting of such notices shall be guilty of a misdemeanor. This provision should not apply to camp fires built in safe places and extinguished before leaving, or to log piles, stumps, and brush located at least a quarter of a mile from other combustible material.

However, the escape of fire from such camp fires, log piles, stumps, or brush should be *prima facie* evidence that the burning was unsafe and in violation of the statute.

Section 11* of the present law provides that " nothing contained in this Act shall take away or impair the right to damages or other legal remedy which the party injured may now have under the laws of this State." This would be strengthened by adding the provision that the liability of persons or corporations for all damages shall include the injury to young growth resulting from fires, and that, upon request of the court, the State Forester shall make an examination and give an expert opinion as to the amount of damages to forest growth. It should also be provided that in a prosecution for the willful or negligent setting fire to forests, it shall be within the discretion of the court to take evidence as to the cost of fighting the fire which the accused is charged with setting, and to assess such costs as part of the penalty if the person or persons charged with the offense shall be found guilty.

The railroads should be required to post in stations warning notices, furnished by the State Forester, calling attention to the fire laws. Section 14 of the 1907 law, which provides that logging locomotives must be furnished with spark arresters, is unjust in that it discriminates against a particular class. This provision should be extended to cover all locomotives and engines operating in or near forest land not burning oil for fuel.

(2) The forestry law of 1907 authorizes the State Game Warden to collect statistics in regard to forest conditions, to investigate the suitability of public lands for forest reserve purposes, to take charge of such reserves as might be created, and to accept gifts of land for forest reserves. These duties lie naturally within the province of the State Board of Forestry, and should be transferred to that board, to be administered by the State Forester under its direction. Further authority should be given the board to make rules and regulations for the State forests, including the right to sell timber. In the case of sales amounting to over $100 in value, advertisement for bids should be required.

The sections† in regard to forest reserves should be so modified as to permit the use of mineral land for this purpose, the mineral rights to be retained by the original owner, if the land is acquired by purchase or gift. Section 23 makes it necessary for a nonresident of the State to obtain the services of a warden as guide in case he wishes to camp within the State forest reserves. This section should be repealed, since regulations safeguarding the camping privilege can best be made by the State Board of Forestry, which should be given the necessary authority.

---

* Acts of 1907, Chapter 397.

† Sections 21 and 22.

The State now owns two tracts of land suitable for forest reserve purposes—the Brushy Mountain tract, in Morgan County, and the Herbert Domain, in Cumberland and the adjoining counties on the southwest. The former is about 12,000 acres in area, and includes 3,000 acres of practically virgin timber. The Herbert Domain covers between 10,000 and 11,000 acres, but the timber probably does not exceed the amount that is likely to be needed for the development of coal mines on the property. Both of these tracts should be handled so as to produce as much timber as possible in the long run. The Board of Prison Commissioners, which now controls these lands, has no authority to sell timber or practice forestry. It is recommended that the surface and timber on these tracts be turned over to the Board of Forestry to administer as State forests. Thus an opportunity may be given to start at once valuable object lessons in the practice for forestry, as well as experimental investigations. It would also make it possible to stop the loss now incurred by the State through the decay of overmature timber, which cannot be sold under existing statutes. It is further recommended that the Board of Forestry be authorized to purchase land for State forest purposes, at a rate not to exceed $5 an acre. This authority would probably not be exercised for the present, at least, owing to lack of sufficient funds at the disposal of the board, but would be desirable in case any small tract is needed in connection with the administration of lands now owned by the State and made State forests in accordance with these recommendations.

(3) The need for educational work by the State Forester, particularly in regard to fire protection and the introduction of conservative methods of forest management, has already been clearly brought out. Special emphasis should be laid on the damage done in stock-raising sections by the practice of burning the woods every year in order to keep down the brush and to get new grass earlier in the spring. Not only does the forest growth deteriorate under such treatment, but the more nutritious annuals and winter grasses are gradually replaced by tougher perennials, so that the grazing

interests eventually suffer. Since much serious injury results from these causes, it should certainly be within the power of the landowner to regulate or prevent grazing on his own property. This is not possible in the counties which have not secured the passage by the Legislature of a law prohibiting stock from running at large. These are, for the most part, in the more thinly populated districts with large areas of woodland. The permanent welfare of such counties requires the passage of stock laws. Educational work along this line, supplemented by an investigation to demonstrate the injurious effect of annual fires on the quality of the grasses, would be an important duty of a State Forester.

The State Forester should be give authority to assist private owners at their request, also by making plans for conservative management of woodlands and advising in regard to the execution of such plans, provided that the applicant in each case pays at least the expenses of the field work that may be necessary. A careful record should be kept of the results secured by such working plans, which would furnish practical examples of what may be accomplished by rational management of woodlands.

(4) The State Forester should, of course, take charge of the investigation of forest problems within the State. The most important subjects for investigation in the different regions have already been mentioned. In connection with such studies, it should be possible to make detailed forest surveys and estimates of some of the typical timber counties as a start toward a forest type map and description of the State. The map work should be done in considerable detail, showing cleared land and types of forest. If this were done independently of other work, it would cost about $400 to map and estimate a county. It is recommended, however, that if such surveys are undertaken at all, it be in connection with investigations of special problems. The State Forester should be authorized to cooperate with the Federal Government and with other branches of the State Government in scientific investigations, when this can be done to the advantage of the State.

The expense of carrying out the forest policy outlined naturally divides itself into two parts—the cost of the State Forester's office in educational, scientific, and administrative work, and the cost of fire protection. The first should be met by a State appropriation of $10,000 annually. This should be supplemented by a State forest fund, into which all receipts from the sale of timber on the State forests and fines for violations of the forestry laws would be paid.

This fund should be used in the protection, improvement, and extension of the State forests. In emergency cases the State Forester should have the right to draw upon it for fighting fire in a county which has exhausted its annual allowance for this purpose.

The cost of the general fire protective system should be shared equally between the State and the individual counties in which the money is spent. This division prevents the placing of too great a burden on more thinly populated counties, and is perfectly fair, since the protection of the forests benefits indirectly the entire State as well as the individual counties. To secure promptness in payment of fire fighters, the State should pay the accounts and collect one-half from the county in which they were incurred. The rate of compensation for fighting fire is fixed in the present law at $3 a day. This is unnecessarily high, and might be an inducement to set fires in order to get employment in putting them out. It is recommended that the rate be changed to 20 cents an hour, and that the county and deputy wardens be paid at the rate of 25 cents an hour for time actually employed in patroling, fighting fire, posting notices, making reports, or doing other official work. They should also be reimbursed for reasonable expenses for necessary equipment and transportation. All accounts, including those for wages, should be approved by the State Forester before payment. The amount to be spent for fire protection in any county in any one year might be limited to $200, and in the entire State to $10,000. On this basis the total cost to the State of the forest policy recommended would not exceed $15,000 per year, and the cost to any one county would not exceed $100 per year, while the maximum total expense per year would be $20,000. This expenditure is to be regarded as an investment, the returns to come in the saving of loss through fire, in the increased productivity of the woodlands, and in the maintenance of wood-using industries.

APPENDIX I.

LIST OF TREE SPECIES NATIVE TO TENNESSEE.

The following list of tree species native to Tennessee is compiled from Sudworth's Check List (Forest Service Bulletin 17), supplemented by the observations of the author and of W. W. Ashe, of the Forest Service. After the scientific name, first the accepted common name according to the Check List, is given, and then any local names that are commonly used within the State. In case the species is not listed in the Check List, merely local names are given. The letters E, M, and W indicate the divisions of the State within which the species occur, whether East, Middle, or West Tennessee.

Pinus strobus, Linn.	White pine	E
Pinus taeda Linn.	Loblolly pine Old-field pine	E
Pinus rigida Mill.	Pitch pine	E
Pinus virginiana Mill.	Scrub pine Black pine Nigger pine	E M
Pinus pungens Michx, f.	Table-mountain pine	E M
Pinus echinata Mill.	Short-leaf pine Yellow pine	E M W
Picea mariana (Mill.) B. S. P.	Black spruce Balsam	E
Picea rubens Sargent	Red spruce Balsam	E
Tsuga canadensis (Linn.) Carr	Hemlock Spruce pine	E M
Tsuga caroliniana Engelm.	Carolina hemlock Spruce pine	E
Abies fraseri (Pursh) Lindl.	Fraser fir She Balsam	E
Taxodium distichum (Linn.) Rich.	Bald cypress	W
Taxodium distichum imbricarium (Nutt.) Sarg.	Pond cypress	W
Thuja occidentalis Linn.	Arborvitæ White cedar	E
Juniperus virginiana Linn.	Red Juniper Red cedar	E M W
Juglans cnierea Linn.	Butternut White walnut	E M W
Juglans nigra Linn.	Black walnut	E M W
Hicoria pecan (Marsh) Britton	Pecan (hickory)	W
Hicoria minima (Marsh) Britton	Bitternut (hickory) Pignut hickory	E M W
Hicoria aquatica (Michx. f.) Britton	Water hickory Bitter pecan	W
Hicoria ovata (Mill.) Britton	Shagbark (hickory)	E M W

Hicoria carolinae-septentrionalis Ashe	Shagbark hickory	E
Hicoria laciniosa (Michx. f.) Sargent	Shellbark (hickory) Kingnut	M W
Hicoria alba (Linn.) Britton	Mockernut (hickory) White hickory	E M W
Hicoria glabra (Mill.) Britton	Pignut (hickory) Black hickory	E M W
Hicoria odorata (Marsh.) Sargent	Small pignut (hickory) Black hickory	E M W
Hicoria villosa (Sarg.) Ashe	Pale-leaf hickory Sand hickory	E M W
Salix nigra Marsh.	Black willow	E M W
Salix wardi Bebb.	Ward willow	M
Salix amygdaloides Anderss	Almond-leaf willow	W
Salix discolor Muehl.	Glaucous willow	W
Populus grandidentata Michx.	Large-tooth Aspen Poplar	E
Populus heterophylla Linn.	Swamp cottonwood Black cottonwood	W
Populus deltoides Marsh.	(Common) Cottonwood	E M W
Betula nigra Linn.	River birch	E M W
Betula lutea Michx. f.	Yellow birch	E
Betula lenta Linn.	Sweet birch Black birch	E M
Ostrya virginiana (Mill.) Koch	Hornbeam Ironwood	E M W
Carpinus caroliniana Walt.	Blue beech	E M W
Fagus atropunicea (Marsh.) Sudworth	Beech	E M W
Castanea pumila (Linn.) Mill.	Chinquapin	E M W
Castanea dentata (Marsh.) Borkh.	Chestnut	E M W
Quercus alba Linn.	White oak	E M W
Quercus Minor (Marsh.) Sarg.	Post oak	E M W
Quercus macrocarpa Michx.	Bur oak Overcup oak	M W
Quercus lyrata Walt.	Overcup oak Bur oak	M W
Quercus prinus Linn.	Chestnut oak	E M W
Quercus acuminata (Michx.) Houba	Chinquapin oak	E M W
Quercus platanoides (Lam.) Sudworth	Swamp white oak	E

Quercus michauxii Nutt.	Cow oak Bur oak	E M W
Quercus rubra Linn.	Red oak Water oak	E M
Quercus texana Buckl.	Texan oak Red oak	M W
Quercus coccinea Muenchh.	Scarlet oak Spotted oak	E M
Quercus velutina Lam.	Yellow oak Black oak	E M W
Quercus digitata (Marsh) Sudworth	Spanish oak Red oak	E M W
Quercus palustris Muenchh.	Pin oak	M W
Quercus marilandica Muenchh.	Black jack	E M W
Quercus nigra Linn.	Water oak	M W
Quercus imbricaria Michx.	Shingle oak	M W
Quercus phellos Linn.	Willow oak	M W
Quercus pagodaefolia Ashe	Swamp Spanish oak Red oak Yellow-bottom oak	M W
Ulmus crassifolia Nutt.	Cedar elm	E M
Ulmus pubescens Walt.	Slippery elm Red elm	E M W
Ulmus serotina Sargent	Bluff elm	E M
Ulmus americana Linn.	White elm	E M W
Ulmus racemosa Thomas	Cork elm	M W
Ulmus alata Michx.	Wing elm	E M W
Planera aquatica (Walt.) Gmel.	Planertree	W
Celtis occidentalis Linn.	Hackberry	E M W
Celtis georgiana Small	Georgia hackberry	M
Celtis mississippiensis Bosc.	Sugarberry Hackberry	E M W
Celtis smallii Beadle	Hackberry	E
Morus rubra Linn.	Red mulberry	E M W
Magnolia glauca Linn.	Sweet magnolia Swamp magnolia	E M W
Magnolia acuminata Linn.	Cucumber tree	E M
Magnolia macrophylla Michx.	Large-leaf umbrella	E M
Magnolia tripelata Linn.	Umbrella tree	E M

Magnolia fraseri Walt.	Fraser umbrella Indian physic	E
Liriodendron tulipifera Linn.	Tulip tree Yellow poplar White wood	E M W
Asimina triloba (Linn.) Dunal.	Pawpaw	E M W
Sassafras sassafras (Linn.) Karst.	Sassafras	E M W
Hamamelis virginiana Linn.	Witch hazel	E M W
Liquidambar styraciflua Linn.	(Red or) Sweet gum	E M W
Platanus occidentalis Linn.	Sycamore Buttonwood	E M W
Pyrus coronaria Linn.	Sweet crab	E M W
Pyrus ioensis (Wood) Bailey	Iowa crab	M W
Pyrus angustifolia Michx.	Narrow-leaf crab	E M
Pyrus americana (Marsh.) de C.	Mountain ash	E
Amelanchier canadensis (Linn.) Medic.	Serviceberry Shad-bush	E M W
Crataegus punctata Jacq.	Dotted haw	E M W
Crataegus cordata (Mill.) Ait.	Washington haw	E M W
Crataegus viridis Linn.	Green haw	M W
Prunus americana Marsh.	Wild plum	E M W
Prunus hortulana Bailey	Garden wild plum	M W
Prunus angustifolia Marsh.	Chickasaw plum	E M W
Prunus pennsylvanica Linn. f.	Wild red cherry	E
Prunus virginiana Linn.	Choke cherry	E M W
Prunus serotina Ehrh.	Black cherry	E M W
Cercsi canadensis Linn.	Redbud Judas tree	E M W
Gleditsia triacanthos Linn.	Honey locust	E M W
Gleditsia aquatica Marsh.	Water locust	M W
Gymnocladus dioicus (Linn.) Koch.	Coffeetree	M W
Cladrastis lutea (Michx. f.) Koch.	Yellow wood	E M
Robinia pseudacacia Linn.	Locust	E M W
Robinia viscosa Vent.	Clammy locust	E
Ptelia trifoliata Linn.	Hoptree	E M W
Cotinus cotinoides (Nutt.) Britton	American smoketree	E
Rhus hirta (Linn.) Sudworth	Staghorn sumach	E M

Rhus copallina Linn.	Dwarf sumach	E M W
Rhus vernix Linn.	Poison sumach	E M W
Ilex opaca Ait.	American holly	E M W
Ilex decidua Walt.	Deciduous holly	E M W
Ilex monticola Gray	Mountain holly	E
Euonymus atropurpureus Jacq.	Waahoo Burning bush	E M W
Acer spicatum Lam.	Mountain maple Low maple	E
Acer pennsylvanisum Linn.	Striped maple	E
Acer saccharum Marsh.	Sugar maple Sugar tree	E M W
Acer saccharum rugelii Rhed.	Sugar maple	E
Acer saccharum nigrum (Michx. f.) Britton	Black maple	E M W
Acer saccharum leucoderme (Small) Sudworth	White-bark maple Sugar maple	E
Acer saccharinum Linn.	Silver maple Soft maple	E M W
Acer rubrum Linn.	Red maple Soft maple	E M W
Acer rubrum tridens Wood	Red maple	E M
Acer negundo Linn.	Boxelder	E M W
Aesculus glabra Willd.	Ohio buckeye	E M W
Aesculus octandra Marsh.	Yellow buckeye	E M W
Aesculus austrina Small	Buckeye	W
Rhamnus caroliniana Walt.	Yellow burkthorn	E M W
Tilia americana Linn.	Basswood Linn	E M W
Tilia heterophylla Vent.	White basswood Linn	E M
Tilia eburnea Ashe	Linn basswood	E
Aralia spinosa Linn.	Angelica tree Hercules Club	E M W
Cornus florida Linn.	(Flowering) Dogwood	E M W
Cornus alternifolia Linn. f.	Blue dogwood	E
Nyssa silvatica Marsh.	Black gum	E M W
Nyssa aquatica Linn.	Cotton gum Tupelo	W

Vaccinium arboreaum Marsh.	Tree huckleberry	E M W
Oxydendron arboreum (Linn.) de C.	Sourwood Sorrel tree	E M W
Kalmia latifolia Linn.	Mountain laurel	E
Rhododendron maximum Linn.	Great rhododendron Rosebay Great laurel	E
Bumelia lanuginosa (Michx.) Pers.	Shittimwood Gum elastic	W
Diospyros virginiana Linn.	Persimmon	E M W
Mohrodendron carolinum (Linn.) Britton	Silverbell tree	E M W
Fraxinus quadrangulata Michx.	Blue ash	E M W
Fraxinus americana Linn.	White ash	E M W
Fraxinus biltmoreana Beadle	Biltmore ash	E
Fraxinus pennsylvanica Marsh.	Red ash	E M
Fraxinus profunda Bush	Pumpkin ash	M W
Fraxinus lanceolata Borkh.	Green ash	E M W
Catalpa speciosa Warder	Hardy catalpa	M W
Viburnum lentago Linn.	Sheepberry	E
Viburnum prunifolium Linn.	Nannyberry	E M

APPENDIX II.

GROWTH OF WHITE AND CHESTNUT OAKS.

The following extracts from Forest Service circulars contain information in regard to the growth of white and chestnut oaks, based on measurements obtained, for the most part, in Tennessee. They are reprinted here on account of the scientific and practical value of the tables.

WHITE OAK.*

The most important feature of the growth of white oak, as well as the most significant characteristic of the tree, is its inherent persistence. The growth of white oak is comparatively slow. Young trees are often outstripped and suppressed by other species. They will, however, grow slowly, but persistently, for many years under adverse conditions.

In white oak the duration of vigorous growth is greater than in any of its associates except yellow poplar and possibly chestnut. It retains its vigor and resistent qualities to an advanced age. For these reasons white oak in the long run overcomes and replaces in the mature virgin stands the black and red oaks, which have such a marked advantage over it in early life. As a rule, in virgin woods, the proportion of white oak increases steadily in the older-age classes. It often forms the bulk of the mature timber in stands where but 10 per cent of the young growth is white oak.

---

* Circular 105, "White Oak in the Southern Appalachians."

The very slow rate of growth of white oak seedlings under virgin forest, as well as their persistence under adverse conditions, is shown in the last column of Table 1. It is based upon measurements of seventy-seven white oak seedlings in virgin coves in the Holston Mountains of Northeastern Tennessee. The forest in this case was exceptionally dense, and the rate of growth is undoubtedly much lower than the average on virgin lands in the region as a whole. The growth of white oak seedlings, however, is slower than that of seedlings of most of the important timber trees associated with it. Under similar site conditions, young black and red oak will almost invariably outstrip white oak.

The rate of growth in height of white oak sprouts under virgin woods is given in the three middle columns for the cove and slope types of the Cumberland Mountains and for the cove type of the Holston Mountains.

TABLE 1.—HEIGHT OF YOUNG WHITE OAK AT DIFFERENT AGES IN EASTERN TENNESSEE.

AGE	CUMBERLAND MOUNTAINS		HOLSTON MOUNTAINS	
	Sprout		Sprout	Seedlings
	Cove	Slope	Cove	Cove
Years	*Inches*	*Inches*	*Inches*	*Inches*
1	13.0	12.5	10.0	4.0
2	40.0	26.0	16.5	5.5
3	57.0	39.5	21.0	6.8
4	70.0	48.2	24.0	8.0
5	82.0	56.0	26.7	9.0
6	....	....	29.0	10.0
7	....	....	31.0	10.8
8	....	....	33.0	11.7
9	....	....	35.0	12.4
10	....	....	36.6	13.0

The sprouts measured upon the cove lands of the Holston Mountains were growing under an old stand of unusual density, which accounts for their comparatively slow rate of growth. These figures can be compared directly with those for the rate of growth of white oak seedlings, which were obtained from exactly the same coves. By such comparison it is seen that under the same conditions as to soil, moisture, and light, the sprouts of white oak grow about three times as fast during the first ten years as the seedlings.

The rate of growth of young white oak sprouts, while vigorous, is considerably less rapid than that of chestnut and of black oak and red oak. Instances are frequently found in the oak belt of Central and Western Tennessee and Kentucky where white oak sprouts have been outstripped in growth and badly suppressed by black and red oak sprouts of the same age.

Table 2 shows the growth in diameter of virgin white oak up to 21 inches. It is based on measurements of 509 trees taken in Jackson County, Ky., but represents the average rate of diameter growth of white oak throughout the Southern Appalachian region.

TABLE 2.—HEIGHT AND DIAMETER OF VIRGIN WHITE OAK AT DIFFERENT AGES.

AGE	Height	Diameter breast high
Years	*Feet*	*Inches*
20	11	1.1
30	18	2.2
40	25	3.2
50	31	4.2
60	38	5.3
70	44	6.3
80	49	7.4
90	55	8.5
100	60	9.7
110	65	11.0
120	69	12.3
130	72	13.5
140	74	14.7
150	76	15.4
160	79	16.8
170	82	17.8
180	84	18.9
190	85	19.9
200	87	21.0

The development of second-growth white oak after logging, with much better light conditions, is considerably faster than that of virgin timber. Measurements of second-growth white oak were obtained in Decatur County, Tenn., on lands which were cut clean for charcoal from fifty to sixty years ago. The rate of growth of this young timber in height, diameter, and volume is given in Tables 3 and 4.

TABLE 3.—RELATION OF HEIGHT AND DIAMETER TO AGE OF SECOND-GROWTH WHITE OAK IN DECATUR COUNTY, TENN.

AGE	Height	Diameter breast high
Years	*Feet*	*Inches*
5	6	0.2
10	12	1.0
15	19	2.0
20	25	3.3
25	31	4.6
30	37	5.9
35	44	7.1
40	50	8.3
45	56	9.4
50	61	10.3
55	66	11.2
60	70	11.7
65	73	12.2
70	74	12.6
75	75	12.9
80	76	13.2
85	77	13.4
90	78	13.6

TABLE 4.—VOLUME *a* OF SECOND-GROWTH WHITE OAK OF ALL TYPES, DECATUR COUNTY, TENN.

Diameter breast high	All types	Diameter breast high	All types
Inches	*Board feet*	*Inches*	*Board feet*
10	24	15	106
11	34	16	130
12	47	17	155
13	65	18	180
14	85		

a Logs scaled by Doyle's rule.

The better soil and moisture conditions found on the cove and slope lands produce more rapid growth in height and diameter than on the ridges, and much more rapid volume increment.

CHESTNUT OAK.*

The rate of growth of chestnut oak is slower both in height and diameter than that of any of the associated oaks. This and its intolerance account for its being so largely excluded from the shady coves. Table 5 shows the development in diameter, total height, and clear length of trees in the virgin forest of the slope type in Polk and Monroe Counties, Tenn. The growth, as shown in this table, seems, on comparison with measurements made in other portions of the region of slope, ridge, and cove trees, to represent about the average rate of growth for virgin timber throughout the region. Second-growth trees and trees which have had more favorable light conditions in culled forests would show much more rapid diameter increment at least.

TABLE 5.—TOTAL HEIGHT, CLEAR LENGTH, AND DIAMETER GROWTH OF VIRGIN CHESTNUT OAK IN POLK AND MONROE COUNTIES, TENN.

Age	Diameter breast high	Total height	Clear length	Age	Diameter breast high	Total height	Clear length
Years	*Inches*	*Feet*	*Feet*	*Years*	*Inches*	*Feet*	*Feet*
20	1.2	12	5	120	12.0	63	24
30	2.4	19	8	130	13.0	65	24
40	3.4	25	11	140	13.9	67	25
50	4.3	31	13	150	14.9	69	25
60	5.4	36	15	160	15.8	70	26
70	6.5	41	17	170	16.7	72	26
80	7.7	47	19	180	17.5	73	26
90	8.8	52	21	190	18.4	74	27
100	10.0	57	22	200	19.3	75	27
110	10.9	60	23				

---

* Circular 135, "Chestnut Oak in the Southern Appalachians."

Table 6 contains average figures for the rate of growth of seedling sprouts and seedlings of chestnut oak for the first ten years in virgin woods. Two localities were studied—the Cumberland Mountains, of Claiborne County, Tenn., and the Holston Mountains, in Sullivan County, Tenn. Separate averages were made for each locality by types.

TABLE 6.—HEIGHT GROWTH OF YOUNG CHESTNUT OAK.

AGE	Cumberland Mountains, slope, and ridge, seedling coppice (101 trees)	HOLSTON MOUNTAINS			
		Slope and ridge, seedling coppice (90 trees)	Slope, root suckers (29 trees)	Cove	
				Seedling coppice (43 trees)	Seedlings (30 trees)
	Inches	*Inches*	*Inches*	*Inches*	*Inches*
1 year	13	12	6	9	5
2 years	30	22	7	21	7
3 years	46	38	8	33	8
4 years	62	61	9	44	9
5 years	76	75	9	53	10
6 years	89	....	10	59	11
7 years	100	....	10	64	12
8 years	....	....	11	....	13
9 years	....	....	11	....	13
10 years	....	....	12	....	14

From this table the rate of growth of seedlings and seedling sprouts of chestnut oak in the same locality and type can be directly compared. Such comparisons show the rate of growth of seedling coppice in height to be from three to five times as rapid as that of seedlings. The rate of growth of root suckers is seen to run slightly less than that of seedlings.

The following tabular statement, made from measurements taken in different portions of Tennessee and North Carolina, shows the average height, clear length, and diameter breast high of old chestnut oak growing under different conditions. Each measurement is averaged from a number of trees in the same locality, growing under the same conditions, but, except in the ridge trees measured in Jackson and McDowell Counties, N. C., only averages of mature trees above 20 inches are included.

County and State	Trees growing in coves			Trees growing on slopes			Trees growing on ridges		
	Average height	Average clear length	Average diameter	Average height	Average clear length	Average diameter	Average height	Average clear length	Average diameter
	Feet	*Feet*	*Inches*	*Feet*	*Feet*	*Inches*	*Feet*	*Feet*	*Inches*
Sullivan County, Tenn.	102	42	32	77	35	31	....	....	....
Claiborne County, Tenn.	90	45	32	60	30	24	59	19	22
Perry County, Tenn.	85	40	23	75	30	23	51	20	23
Jackson and McDowell Counties, N. C.	81	34	24	....	....	....	*a* 21	7	6

a Includes trees with diameters less than 20 inches.

The relation of total height to clear length, showing the extent of self-pruning, is also observable. The relative length of crown on the several types is exhibited, and the greater sizes attained in the cove type than in the slope or ridge type.

The largest dimensions are attained along and west of the Allegheny and Cumberland Mountains, in West Virginia, Kentucky, and Tennessee. Individual specimens occasionally reach a height of 115 and 118 feet, and maximum diameters of 50 and 52 inches.

2

10—B (Of Tenn. Geol. Surv. Series)

STATE OF TENNESSEE—STATE GEOLOGICAL SURVEY
GEORGE H. ASHLEY, State Geologist

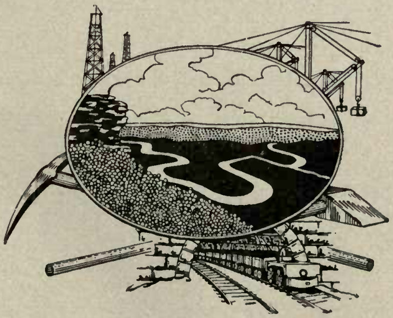
IN COOPERATION WITH THE FOREST SERVICE
U. S. DEPARTMENT OF AGRICULTURE
HENRY S. GRAVES, Forester

CHESTNUT IN TENNESSEE

BY

W. W. ASHE

FOREST ASSISTANT, FOREST SERVICE



(PUBLISHERS)
BAIRD-WARD PRINTING CO.
NASHVILLE, TENN.
JANUARY 1911

The study upon which this report is based was undertaken by the State Geological Survey in cooperation with the Forest Service, the work being done under the direction of the Office of State Cooperation in the Forest Service and under the local instructions of the Director of the Survey. By the terms of the cooperation agreement the State is authorized to publish the findings of the investigation.

CONTENTS

	Page
Commercial outlook	5
Distribution	6
Silvical characteristics	6
Soil and moisture requirements	6
Temperature and light	8
Reproduction	8
Production of seed	8
Seedling production	9
Sprouting	9
Root system	10
Diseases and defects	10
Forest types and associated trees	11
Growth of individual trees	12
Management	14
Protection	16
Improvement cuttings	17
Thinnings	17
Comparative yield of thinned and unthinned stands	18
Clean cutting and culling	19
Uneven-aged stands	20
Even-aged stands	23
Cordwood	23
Pole ties	26
Poles	30
Saw timber	31
Relation of board feet to cubic feet and cords	33
Summary	34

Chestnut in Tennessee

COMMERCIAL OUTLOOK

Chestnut, because of the extensive and rapidly increasing use of its wood as a source of tanning material, has become one of the most important forest trees of Tennessee. There are now seven tannic extract plants in operation within the State, and all use chestnut wood and bark, though some use in addition, the wood or bark of chestnut oak. To supply these plants more than 50,000 cords of wood are cut yearly in Tennessee with a value of about $187,500 at the shipping points. In addition to the extensive use of the wood for tannin, the census of 1909 reports 71,962,000 feet of chestnut lumber cut in Tennessee, with a mill value of $1,121,888. There were also produced 120,000 sets of heading valued at $5,520, and a large number of staves, ties, and poles valued at not less than $325,000. On a most conservative basis the chestnut is, therefore, worth $1,640,000 annually to the State. With the continued reduction in the available supply of other native tannin materials, the chief of which are hemlock and chestnut oak bark, chestnut must become the chief remaining source of supply, and its use will increase. Since low grade chestnut wood and small-sized pieces, including the bark, can be used for tannin stock, this industry in connection with lumbering, permits the complete utilization of the tree. Chestnut has a comparatively rapid growth; it occupies extensive areas either in pure stands or as the dominant species in mixed stands; it grows on land which has a comparatively low value for agriculture, and reproduces freely by sprouts as well as by seed. These are natural advantages which the tree offers for management. Further, its yield can be largely augmented by protecting the forest from fire, and by thinning young stands; and the value of the forest can be additionally enhanced by systems of cutting designed to produce the most valuable class of commercial products. All these things combine to make the commercial management of chestnut forests a feasible and profitable undertaking.

DISTRIBUTION

Chestnut is commercially important throughout middle and eastern Tennessee and as far west as Perry and Stewart Counties; farther west it is comparatively unimportant. It is most abundant on the slopes of the Unaka and Smoky Ranges embracing the Great Smoky, Unaka, Stone, and Iron Mountains, and on such outlying ranges as the Holston, Frog, and Yellow Mountains. In many places in all of these mountains it forms as much as twenty-five per cent of the forest over tracts several thousand acres in extent. In the Unaka and Smoky Ranges it is locally most abundant on elevated benches of the north and west slopes and on the crests of northern spurs, between altitudes of 1,800 and 3,500 feet. In such situations it may occur pure or nearly pure over areas as large as 100 acres. Between the Unakas and the Cumberland Plateau chestnut forms less than 15 per cent of the timber. Here it is largely confined to hollows and north slopes, and pure stands rarely occupy more than a few acres. On the valley lands, irrespective of soil, it constitutes less than 5 per cent of the forest. It is common on the slopes of the Cumberland tableland, especially on the sandstone soils which have a sufficient depth and are not too rocky; in such situations it forms a large portion of the forest. Chestnut is almost entirely absent, however, on the thin-soiled and stony portions of the tableland, especially near the southern end. In Claiborne, Campbell, Anderson, Morgan, and Cumberland Counties it forms possibly 15 per cent of the timber.

Chestnut constitutes only a small proportion of the forests of the Central Basin, but is one of the chief trees of the Highland Rim. In portions of Hickman County, which occupies a typical situation on the western part of the Highland Rim, 10 per cent of the forest aggregating several thousand acres, consists of chestnut. On the sandier soils of the Highland Rim chestnut comprises up to 20 per cent of the forest on the better sites.

SILVICAL CHARACTERISTICS

Soil and Moisture Requirements:

Chestnut requires for its best growth, deep, moist loams or sandy loams. The soils on which it grows must be of considerable depth to permit the penetration of its ample, deeply ramifying roots, and must be moderately supplied with moisture in the subsoil, but well drained on the surface. It seldom grows on clay soils, and practically never on limestone soils. On clay soils it grows only where the surface of the land is sufficiently rolling to insure surface drainage, and even then it forms only a small proportion of the forest growth. It makes excellent growth on highly acid soils where it is frequently associated with rhododendron (laurel) on north slopes, or with kalmia (ivy) on west slopes, but it also grows in pure stands. Although less exacting than yellow poplar, walnut or ash, in respect to depth of soil and amount and uniformity of moisture supply, it is more exacting than white oak, by which it is replaced on the drier soils, even where there is considerable depth. On the thoroughly drained sandy or gravelly soils it gives way on cool slopes to white pine, and on somewhat stiffer soils to scarlet oak, especially at middle elevations, and to black oak at lower elevations.

While chestnut is exacting in regard to depth and porosity of soil, and makes moderate demands upon soil moisture, it does not require either a sweet or a fertile soil. Unlike poplar, basswood, and ash, it will grow thriftily upon sandy soils with a subsoil deficient in lime as well as potash, and in addition to its capacity for germinating and growing on the peaty soil of the rhadodendron (laurel) thickets, it does well also on soils with scant humus cover. In these respects it is one of the least exacting of the hardwoods. Of species which require a deep soil, it is intermediate between species like yellow poplar, ash, and walnut, which require considerable soil fertility and the less exacting white and short leaf pines.

As a rule, especially at altitudes between 1,000 and 3,000 feet, chestnut occupies soils which are too acid and sandy to be of high agricultural value unless limed. On the other hand, the soils within these altitudes which are more uniformly moist in the subsoil and are neutral or only slightly acid, such as are occupied by yellow poplar, walnut and locust, are regarded as well suited for farming purposes. At altitudes below 1,000 feet, the soils usually occupied by shortleaf pine, black oak, and hickory, are also considered superior for general farming purposes, to those occupied by chestnut. Above 3,000 feet altitude much of the soil occupied by chestnut is regarded as of good quality for pasture land, if set in redtop (herds) grass, which will grow on more acid soils than will clover and bluegrass.

TEMPERATURE AND LIGHT

Chestnut is adapted to a wide range of climatic conditions. It flourishes from an altitude of less than 500 feet elevation in southwestern Tennessee, where the average annual temperature is 59 degrees Fahrenheit (the mean of the summer maxima 89 degrees, and the winter minimum seldom as low as zero), to elevations of more than 5,500 feet along the Smoky and Unaka Mountain ranges, where the average annual temperature is below 50 degrees (the mean of the summer maxima not more than 80 degrees, and the winter minimum frequently 30 degrees below zero). Its best growth, however, is on moderately cool sites, such as shady slopes, coves, and elevated benches of the eastern mountains between 1,000 and 3,000 feet in altitude. Here it not only attains its maximum dimensions, but is numerically more abundant, occupying large areas to the practical exclusion of other species. Rainfall has but little effect on its distribution, since Tennessee has a rainfall which is seldom below 40 inches a year, with an equable seasonal distribution.

REPRODUCTION

For seedling reproduction, chestnut requires only a limited amount of light. The seedlings will persist for many years under the shade of old trees, and when twenty to thirty years old may not exceed 15 feet in height and 3 inches in diameter. As a rule, when the large trees which are overtopping these suppressed seedlings are cut, the seedlings respond quickly to the increased light and make accelerated growth. If suppressed for a great many years, however, the seedlings either die or lose their power of rapidly recuperating when eventually favored by more light. Even though they continue to live, they ultimately develop into slow-growing specimens similar to the large trees which form the present old forest. Although sprouts will grow for a few years under poor light, they ultimately require more light than seedlings, and their best development can take place only under full light. When single scattered trees are cut in a stand of normal density there is frequently insufficient light for the sprouts, which die after a few years.

Production of Seed.—Chestnut bears seed or mast abundantly at intervals of a few years. In intervening years the seed crop is lighter, but seldom entirely wanting. The flowers appear in midsummer, too late to be killed by frost, but rainy weather, during the pollination period, may prevent the setting of the fruit and curtail the crop of nuts. A heavy mast year is usually followed by one of small mast. Even though large quantities of nuts are collected for sale, enough are left on the ground to insure abundant reproduction; these, however, are often eaten by hogs, or burned, and small seedlings that may get started are destroyed by fires and by cattle.

Seedling Reproduction.—The sprouting capacity of chestnut is much more important to its regeneration than its ability to reproduce by seed. Sprouts can be relied upon for reproduction in pure stands or in large groups, or when chestnut is in mixture with other sprout species and is managed on a short rotation. It is necessary, however, to supplement sprouts with seedlings in order to make up for those stumps, whose sprouting power has ceased. Where large timber is desired, as when chestnut is to be grown with oak or poplar for lumber purposes, seedlings are more desirable than sprouts. One-half to two-thirds of full light is most favorable to germination. If the nuts are too exposed they may dry out in the spring before the young root is thoroughly fixed in the soil. It is desirable that nuts lying on the ground in the forest be lightly covered during the winter, not only to keep the kernel moist and in condition to germinate, but to bring it in direct contact with the soil to facilitate rooting. To accomplish this the nuts might be planted or lumbering operations carried on during a season which promises a good mast year; or pigs might be turned in temporarily before the nuts fall. Under ordinary conditions, when nuts are collected for market, the leaves and litter are sufficiently disturbed by the nut gatherers to cover a large number of nuts; and many seedlings are thus assured, unless the nuts left are subsequently destroyed by swine, or the seedlings killed by fire.

Sprouting.—Most vigorous sprouting is obtained from stumps of trees cut in spring, early summer, or late in winter; least vigorous sprouting is secured from trees cut during August and September. Most sprouts appear either immediately at the root collar or just above the ground, and as a rule from partially independent root systems. It is exceptional for sprouts to develop near the tops of stumps. Such sprouts seldom make large and thrifty trees, and since they cannot form an independent root system, they frequently break from the parent stump as they become large and the stump is weakened by decay. Chestnut does not sucker.

The sprouting capacity of chestnut is far superior to that of any other important hardwood growing in Tennessee, and it is exceptional when an unburned stump fails to sprout. On the north slope of Roan Mountain, above Burbank, at an altitude of about 3,000 feet, 99 per cent of stumps of trees 3 to 5 feet in diameter, and varying in age from 150 to 300 years, sprouted, and the sprouts from most of the stumps were both numerous and vigorous. In such a situation chestnut is probably at its best. Several vigorous stands were seen which were composed of the second set of stump sprouts. Stumps should be cut low and obliquely, and the fertility of the soil maintained by preserving the humus. Where this is done and the trees are protected from fire, it is probable that many successions of sprouts can be grown from the same roots before their vigor is exhausted or even seriously impaired. The period of sustained vigor depends on the age at which the successive crops of sprouts are cut, and, to some extent, upon the season of the year.

ROOT SYSTEM

The chestnut seedling has a central tap-root and long lateral, fibrous roots and rootlets. Early in life this tap-root divides into many vertical roots, above which are numerous widely ramifying laterals that lie from 6 to 8 inches below the surface of the ground. In mature trees the roots frequently descend to a depth of 4 or 5 feet. Such a root system firmly anchors the tree and renders it extremely wind-firm.

Diseases and Defects.—Until past the pole stage, chestnut suffers severely from fire because of its thin bark. Sprout trees not only have thinner bark, but are likely to be injured through the burning of the old stumps. Since the sprout stands are those left after lumbering, they have been frequently burned, and the trees are either hollow or defective at the base, although the fire scars may have healed over so that there is no external mark.

In addition to plainly evident physical defects, the exposure of wood following the killing of the bark by fire affords an entrance to destructive insects. The most important of these are the chestnut timber worm* and the two-lined chestnut borer.** The chestnut timber worm causes the common defect known as "wormy chestnut," a defect which greatly reduces the value of much otherwise high grade timber. The two-lined borer kills living trees by girdling them by mining beneath the bark. This pest causes the death of many trees, sound ones as well as those injured by fire.

---

* For information on the chestnut timber worm, see Circular 126 of the United States Bureau of Entomology, "Insect Injuries to the Wood of Living Trees," by A. D. Hopkins.

** For information on the two-lined chestnut borer, see "Injuries to Forest Trees by Flat-Headed Borers," by H. E. Burke, Yearbook, United States Department of Agriculture, 1909.

For many years the chestnut on the lower mountains in the southeastern portion of the State has been dying out, a few trees at a time. Examples of this were noted on the English Mountains, Gray Knobs, Chilhowie Mountain, Stars, Bear, Frog, and Red Mountains. Some of these are killed by the two-lined chestnut borer, but while this decline is in part due to the ravages of the borer, it seems to be due more to excessive burning and to the consequent destruction of humus and impoverishment of the soil. Trees in hollows, on cool north slopes and on land where a moderately dense shade and soil cover exist have not been affected. The remedy for the trouble would seem to be to stop fires, to permit humus to accumulate, and to let the young timber grow up thick enough to shade the soil. The dying off of the trees is certainly not due to the chestnut bark disease (diaporthe parasitica), a very destructive parasitic malady from Virginia to Southern New England, no evidence of which was seen in Tennessee.

Chestnut is seldom thrown by the wind, and the stem rarely breaks unless hollowed at the base by fire. The leaders are sometimes broken by sleet and icestorms, and large branches torn away by windstorms.

FOREST TYPES AND ASSOCIATED TREES

Chestnut enters largely into the composition of five well-marked forest types:

(1) Pure chestnut type with less than one-third of other species.

(2) Lower cove type, with yellow poplar, oaks, basswood (or linn), ash and locust.

(3) Upper cove type, with hemlock, birch, hard maple, beech, ash, and basswood.

(4) Chestnut oak and chestnut type, frequently with scrub pine.

(5) Mixed oak and chestnut type, frequently with yellow pine and sourwood.

Of these five, two are cove types, the upper and lower coves; one, pure chestnut, is a north slope type; and two are ridge or south slope types. These topographic divisions are arbitrary and can be applied only roughly, since topography is but one factor influencing drainage, depth of soil, and temperature, and, consequently, the distribution and local abundance of chestnut. On the north and west slopes chestnut is at its optimum. The upper cove marks the minimum temperature it will endure; in the chestnut oak type it reaches its limit so far as shallowness of soil is concerned, while in the mixed oak type it approaches its minimum limits of soil moisture and compactness of soil.

The proportion of chestnut in the mixed types may amount to as much as 65 per cent or as little as 15 per cent, depending upon conditions of soil, drainage, or climate. In each type, chestnut has a different rate of growth, and the system of cutting must be modified for each to obtain the maximum returns and leave the forest in the best shape for growth and for future cuttings.

Growth of Individual Trees

The growth and yield of chestnut vary greatly according to the situation. Three qualities of situation have been recognized: The first includes the lower cove type and that part of the pure chestnut type, where, on the lower slopes, there are the most rapid-growing stands; the second, or average quality includes the greater portion of the pure chestnut type and some of the stands in both the chestnut oak and chestnut type, and the upper cove type; the third, or poorest quality, includes the mixed oak and chestnut type, and the greater portion of the chestnut oak and chestnut type.

Table 1 shows the rate of height growth of the dominant or tallest trees in stands of sprout chestnut for each of these three classes.

Table No. 1: Growth in height of dominant trees in sprout chestnut stands, based on 117 plats on different sites.

	First Quality.		Second Quality.		Third Quality.	
Age—Years	Height of Trees	Growth in height during preceding decade....	Height of Trees	Growth in height during preceding decade....	Height of Trees	Growth in height during preceding decade....
	Feet.				Feet.	Feet
5	18	..	15	..	12	..
10	33	33	27	27	22	22
15	45	..	37	..	30	..
20	55	22	45	18	36	14
25	64	..	52	..	41	..
30	71	16	58	13	46	10
35	78	..	63	..	49	..
40	84	13	68	10	52	6
45	88	..	71	..	55	..
50	92	8	75	7	57	5
55	96	..	77	..	59	..
60	98	6	80	5	61	4
65	101	..	82	..	63	..
70	103	5	84	4	64	3
75	105	..	85	..	65	..
80	107	4	87	3	66	2

As the table shows, the rate of height growth decreases rapidly as the trees become older. In all qualities more than one-half of the total height growth of dominant trees is made by the twentieth year. The rate of height growth decreases to less than one foot a year by the forty-fifth year in first quality stands; by the fortieth year in second quality stands, and by the thirtieth year in those of third quality. Beyond the seventieth year in all qualities the annual height growth is inconsiderable. In most trees the length of the stem has been definitely fixed before the sixtieth year by its division into branches. Its clear length at this age varies in dominant trees from about 60 feet in first quality stands to 45 feet in third quality. Although the trees continue to grow slowly in height as long as they are alive, the clear length can extend only by the loss of lower branches.

Table 2 shows the growth in diameter of trees of each of the three classes in unthinned, even-aged stands.

Table 2: Growth in diameter of sprout chestnut stands; time required to grow one inch in diameter. Based on 117 sample plots.

	Quality I.		Quality II.		Quality III.	
Diameter, breast-high	Age—	Time to grow 1 inch in diameter	Age—	Time to grow 1 inch in diameter	Age—	Time to grow 1 inch in diameter
Inches	Years	Years	Years	Years	Years	Years
10	26	..	33	..	40	..
11	31	5	39	6	48	8
12	36	5	46	7	59	11
13	41	5	53	7	76	16
14	47	6	61	8	..	..
15	53	6	71	10	..	..
16	59	6	83	12	..	..
17	66	7	..	..	..	..
18	73	7	..	..	..	..
19	81	8	..	..	..	..

The rate of diameter growth decreases uninterruptedly after the first few decades. In stands of the first quality during the first decade it takes only three years to grow an inch; by the fiftieth year it takes six years.

MANAGEMENT.

By the management of a forest is meant the use of a definite system of protection and cutting which seeks to perpetuate it and to increase its productive value. Protection may consist in preventing fires and overgrazing, controlling insect attacks or sparing the young growth during lumbering. A stand may be perpetuated by cutting so as to obtain sprouts or seedlings; it may be cut at a period to develop its maximum yield; it may be thinned to accelerate its growth, or to produce material most suitable for special uses. The same methods of management are not applicable to all conditions.

Chestnut is a large component of several mixed types of forest, although it also forms pure stands. It is found in extensive even-aged stands of second growth, as well as in uneven-aged, old forests; it has a slow rate of growth on poor soils, and on better situations its growth is rapid. Some of it is still quite inaccessible, so that only the large timber is merchantable; other stands are close to market, which makes possible a much more complete utilization. The wood is extensively cut for special uses. Under such a great variety of conditions it is impossible to apply a uniform system of management, and a special system must be developed for each class of forest, if the best results are to be obtained.

The important classes of chestnut forests in Tennessee are:

(1) Uneven-aged stands, consisting mainly of old timber, in which large-sized, overmature, and defective trees often predominate. Most of the old timber is in mixed stands, though there are some pure stands.

(2) Even-aged, second-growth stands, either pure or mixed.

These classes can again be classified according to accessibility; some tracts are near railroads, or connected with farms, or otherwise so situated that close utilization and intensive management is possible; others are distant from shipping points, or cover large areas of rough land, where close utilization at present is not possible.

Forest management of the chestnut in the forests of Tennessee should aim:

(1) To foster chestnut and pine in the mixed stands on the poorer sites at the expense of the slower-growing chestnut oak and white oak.

(2) To get more seedlings of ash, poplar, and red oak in the mixed stands in the hollows, since these species sprout only sparingly, while chestnut will do so abundantly. White pine, also, should be encouraged where it is present. Seedling reproduction of chestnut should be encouraged in the hollows, since seedlings make larger trees than sprouts do.

(3) To maintain on chestnut soils pure sprout stands of chestnut reinforced by seedlings of this species, together with chestnut oak and red oak.

This scheme is based on the supposition that the destructive chestnut bark disease will not reach Tennessee. In the event that it does, cuttings should be made so as to increase the amount of white pine and poplar in the cove type, and the amount of pine on chestnut lands having southern exposures. If the pure chestnut forests are destroyed by this disease, it will be necessary either to plant other species in order to re-establish remunerative forests, or to rely on the slower means of natural reforestation to establish a new growth of other species.

PROTECTION.

Young chestnut is so subject to fire damage that it is of first importance to protect young stands. Old timber with thicker bark is less injured, though it cannot be burned without some injury. While the protection of large tracts is difficult and costly, thick stands and heavy yields of sound timber cannot be obtained unless fires are prevented. There is a striking contrast in the condition of the young timber on repeatedly burned coaled-over land, and the same class of timber in farmers' woodlots which have had few, or no fires. The yield of the burned stands is seldom two-thirds that of protected stands, and the timber is of inferior quality.

Posting the forest fire laws of the State, co-operation with adjoining land owners, and regulating of nut gathering and grazing, all these will help to solve the fire problem. Assistance in fighting fires should be required for the privilege of gathering nuts or pasturing cattle. On large tracts it is possible to maintain a patrol, but it is seldom practicable to establish cleared fire lines. A patrol would undoubtedly be the best manner of protecting recently cut-over land and young timber. Fire guards would be required only during the dry and windy weather, at which times arrangements should be made for securing help promptly when needed. Small tracts, particularly those connected with farms, are more easily protected. Fires are discovered earlier, before they have made great headway, and as a rule assistance for fighting them can more readily be secured. In fighting fire, young timber should be given first consideration, since it is more easily damaged. When clean cutting or heavy culling is practiced, especially summer cutting, it may be necessary to pile and burn slash. This may not be necessary after moderate culling, especially if the trees are not in foliage, or if the tops are closely utilized for extract wood. As a rule it is desirable if hemlock or pine are mixed with chestnut and are cut with it.

Land in process of restocking either by sprouts or seedlings should never be pastured. After it is restocked and the top shoots of the young trees have grown out of reach of stock, limited pasturage can be permitted as in old stands. In any case, the number of cattle grazed should be carefully regulated, especially on recently cut-over land, so that no damage will result.

IMPROVEMENT CUTTINGS.

Improvement cuttings are made for the purpose of removing defective trees, either old or young, and eliminating species of low value. The object in making them is to obtain a stand formed entirely of sound trees of desirable species. As a rule, they can be conducted without cost only where there is a market for material for low grade or small dimensions, and thus they are practically restricted to forests connected with farms or to those near towns, shipping points, and tannic acid extract plants.

In old timber they should remove spreading trees which are overtopping vigorous thickets of young growth, and should reduce the number of seed-bearing trees of slow-growing or low grade species, such as black gum, red maple, beech, and white oak. In second-growth stands they should eliminate trees of slow-growing species, individuals with large overtopping crowns and trees with very crooked or short, forked stems, or sound trees of inferior species should be removed. Small poplar may be cut for pulpwood, and chestnut, and chestnut oak for tannic acid extract works. On the Cumberland tableland, there is a demand for mine props; near towns and on farms fuel affords an excellent opportunity for disposing of the products of improvement cuttings.

THINNINGS.

The object of thinnings is to accelerate growth. Consequently they are of value only to young stands in which the trees will readily respond to them. The smaller and less promising trees, even of chestnut and other desirable species, as well as those of undesirable species, are removed in successive cuttings, leaving a smaller number of very vigorous, well-spaced stems from which are selected the trees that are to form the ultimate mature stand. All cuttings are for the benefit of these select trees, and are made at frequent intervals to prevent any check in their rate of growth. The prolonged struggle between competing trees is thus prevented by greatly reducing the number of stems per acre. The individual trees of the mature thinned stand are probably no taller than those in unthinned stands, but they have so much larger diameters that the yield of merchantable timber is greatly augmented.

Thinnings should begin between the fifteenth and thirtieth year, according to the rapidity of growth, size of trees, and density of the stand. Sprout stands, because of their more vigorous growth during the first few decades, can be thinned earlier than seedling stands. The interval between thinnings should vary from five to ten years, depending upon the rate of growth of the trees and the rapidity with which the crown cover becomes filled. As a rule, frequent light thinnings give better results than heavy ones at long intervals. Trees should be removed evenly through the stand, and large clusters of sprouts should be well thinned. By repeating the thinnings it is possible to maintain practically the same rate of diameter increase for a long period and to prevent the progressive decline which takes place in close, unthinned stands. (Table 2).

Thinnings are seldom profitable unless the wood that is removed can be used, or can be sold for enough to cover the cost. Early thinnings will yield only small wood suitable for fence posts or cordwood. Later thinnings will yield some ties and poles, particularly when the stand is being held for large sized sawtimber.

In order to cut trees to best advantage into hewn ties or into poles, it is necessary to maintain sufficient crowding to prevent the stems from being too tapering and to cut before the butts become too large. In the production of sawtimber it is desirable to obtain the largest diameters. For this reason thinnings to accelerate diameter growth become of even greater importance in providing sawtimber than in stands intended for poles and hewn ties. Thinnings should begin earlier and should be heavier than in stands managed for ties and poles.

It is often advisable to thin the sprouts around large stumps. This can be done during the first winter by breaking off the smaller ones, and leaving vigorous sprouts about one foot apart around the stump.

Comparative Yield of Thinned and Unthinned Stands—A comparison of the thinned and unthinned plots in Table 3 shows the actual results in increasing the merchantable volume of stands even by a thinning which was unsystematic. Had the thinning been systematic, the yield would undoubtedly have been higher, and if these two thinned stands had been removed in two cuttings, made at intervals of from 10 to 15 years, it is probable that their yield could have been increased to 25,000 board feet, or that more than 700 sawed ties 7x7 inches and 8 feet long could have been obtained per acre.

Table 3: Number of trees and yield in lumber or ties per acre, of unthinned and thinned stands in similar situations.

Unthinned Stands.			Yield Per Acre.	
Age—	Trees under 10 inches	Trees 10 inches and over	Lumber—	Ties—
Years	No.	No.	Bd. feet	Number ...
45	220	110	4,220	158
56	184	116	7,980	178

Thinned Stands.			Yield Per Acre.	
Age—	Trees under 10 inches	Trees 10 inches and over	Lumber—	Ties—
Years	No.	No.	Bd. feet	Number
47	84	148	18,800	555
59	52	132	18,728	553

Clean Cutting and Culling—A comparison of even-aged, second-growth stands which have followed clean cutting for charcoal, with second-growth stands of mixed age which have followed cullings, shows the straightest and thriftiest timber on the areas which were clean cut. The competition between trees of the same height on the clean-cut lands is mutually beneficial, resulting in long, straight stems with low taper. In the mixed-aged stands, on the other hand, there are many trees with short, crooked stems and long, wide-spreading crowns, the result of a long period of suppression.

While clean cutting is by no means possible at the present time in the great majority of lumbering operations, it is the ideal method of cutting chestnut, and should be approximated whenever the market will justify it, and when the cut-over land can be protected from fire. When the land has not been grazed and there have been no fires there will invariably be found beneath the old trees an abundance of small seedling chestnuts. This will often obviate the necessity of leaving seed trees of this species in those places where it is necessary to restock with seedlings.

Culling consists in cutting the larger trees and leaving the smaller ones to grow. Its practice is based on the theory that small trees growing near or beneath large trees will recuperate after the cutting of the larger trees and make accelerated growth. This is by no means invariably the case, and when such small trees have passed through a protected period of suppression their rate of growth is permanently impaired. If suppression is not of too long duration—more than 35 years—and if the trees are growing in good soil, they will recover. Their rate of height growth, however, will not be so rapid and their rate of diameter growth will seldom equal that of trees which have grown thriftily from the first. Culling must be relied upon chiefly in cutting forests which can not be thinned, and where there is no market for small wood. It enables moderate cuttings of large timber to be made at comparatively short intervals—15 to 25 years—but it fails to develop the maximum increment. It is suited particularly to seedling stands, since the partial light is unfavorable for the growth of sprouts, but very favorable for the early growth of seedlings. It is the method which must be used in managing a great portion of the mountain forests of large and old chestnut which are cut to a diameter limit. It is desirable to fix a diameter limit, but this, however, should not always be closely adhered to. In some cases it should be used in the nature of a general guide to the cutting limit. Where only sawtimber can be taken, and many large, unsound trees are left, a diameter limit for chestnut of 18 inches is not too high. When poles and ties can be cut the limit can be lowered to 14 inches.

UNEVEN-AGED STANDS.

The situation of a forest in reference to transportation facilities, the possibility of close utilization, and the rapidity of growth determine the method of management and consequently the character of the cutting.

Tracts so inaccessible that there is no present or prospective market for small material should be managed primarily for sawtimber, which can stand a higher cost of logging and transportation. In cutting old timber on tracts which are to be managed primarily for sawtimber, the trees should be cut to a diameter of not less than 18 inches breast high on good sites and 14 inches on poor sites. But even in cutting to such limits considerable discretion should be used. A thrifty young, smooth-barked tree, with a long, straight stem, might well be held over for the second cutting, even if as large as 20 inches in diameter, since such a tree would undoubtedly be making a rapid growth. On the other hand, trees below these diameters, if short-bodied, crooked, and defective, or trees which are shading a thrifty group of young saplings, or crowding a group of poles, might well be cut, even if the profit in cutting them is very small. Thrifty young trees, the cutting of which would yield only a small profit, should be left if the cost of logging is low enough to permit it.

The utilization of large, old timber should be as clean as possible, but it will be impossible to use many of the old trees which are too defective for sawtimber. These can be left, since they will not only serve as seed trees, but may eventually be used for tannic extract stock. In localities where the market is better and where posts, ties, and extract stock can be sold, even if the local transportation must be done by flume or road, the forest can be left in much better condition for future earning value. It will be possible to cut out most of the old, defective trees and convert the seedling stand into a sprout stand, which will have a greater capacity for growth. Seedling chestnuts eight inches or less in diameter should not be cut, however, but should be left to replace exhausted stock at the second cutting. All other species which are mixed in with groups of chestnut, and which can be used, should be cut at the same time as the chestnut in order that the chestnut sprouts may have full light for their growth. When there is a market for poplar or pine pulpwood, seed trees of these species should be left, since they make a good mixture with the chestnut. Red maple and black gum, if taken for paper stock, should be cut to the smallest merchantable diameter. Seed trees of chestnut oak and red oak can be left, but Spanish oak and white oak should be cut to smallest merchantable size.

Timber which has a rate of growth as slow, or slower than that on second-quality sites, should be managed so as to secure even-aged sprout stands. This would apply not only to much of the timber on the south slopes, ridges, and upper north slopes of mountains in the eastern part of the State and the Cumberland plateau, but to chestnut stands as far west as Stewart and Hickman counties. The chestnut on poor sites is largely associated with chestnut oak, which is also a vigorous sprouting species. The poorer the site, the less is the difference in the rate of growth between chestnut and chestnut oak, since chestnut oak is less affected by a poor condition than is chestnut. Managed as sprout forests, these sites can produce timber large enough for extract stock in a comparatively short time, while many trees will become large enough for ties and a few for poles. On the Cumberland tableland, where mine props are used, much of the small timber can be cut for this purpose. The production of larger timber for sawlogs is not advisable, since the growth of the trees becomes too slow after reaching a diameter of 14 to 16 inches. Stands should be cut close, but seedling chestnut 8 inches or less in diameter should be left in a first cutting in order that they may replace exhausted stumps and become old enough to seed. Seed trees of red oak, chestnut oak, and yellow pine should also be left.

When there is no market for tannic extract stock the timber on the ridges should be managed for tie production in sprout stands. It should be managed as seedling stands for sawtimber only where there is no possibility of marketing smaller material which can be grown from sprouts.

In slopes and hollows the rate of growth is usually equal to, or better than that on second-quality sites. On tracts at a distance from shipping points, chestnut should be managed only for sawtimber, poles, or ties, and old timber should be cut in the same general manner as on the ridges. Seedling reproduction should be encouraged. The old trees should be cut, as nearly as market conditions will permit to a minimum diameter of 20 inches for sawtimber, but to 14 inches for ties. All crooked and defective trees which can be used should be cut. As the quality of the soil improves, chestnut becomes relatively less valuable than some other species, such as popular and white pine, and these should be favored so as to have a mixed stand of chestnut and these species.

Near shipping points poles are relatively more valuable than sawtimber, and where there is a certain market for poles old timber should be cut to a diameter of 14 inches, and sprout reproduction, supplemented by seedlings, encouraged. However, it is always advisable to reserve a few large trees of poplar, white pine, red oak or ash.

EVEN-AGED STANDS.

There are in Tennessee probably more than 100,000 acres of even-aged, second-growth chestnut, either in pure stands or where chestnut forms more than one-half of the stand. These are largely sprout forests on old "coalings," which were made to supply charcoal with which to operate forges, furnaces, or smelters. A small number of these stands are in "deadenings," which were never cultivated or were cultivated only a few years. Few of them have resulted from lumberings, but as closer utilization becomes possible, lumbering will approximate clean cutting and even-aged stands of young growth will largely replace the uneven-aged forest. While these even-aged sprout stands give high yields of straight, clean-bodied timber, there is one drawback in their management which cannot be overlooked; that in order to obtain vigorous sprouts it is necessary to cut at the inconvenient seasons of winter, spring, or early summer. If the stumps are cut in autumn many will fail to sprout, and early summer cutting is also objectionable, because the bark from which the sprouts arise is easily separated from the stump, and is likely to be torn off during the lumbering operations.

In the management of even-aged stands yield tables, which show the amount of wood that can be cut at different ages, are necessary. Their chief value is to indicate the age at which stands that have different rates of growth may reach the period of maximum growth, or maturity, and should be cut. It is necessary to determine this age for each product into which the timber can be converted, since the age of maturity varies for various products. Yield tables can also be used for estimating the quantities of material which can be expected from the second-growth stands which will follow after the old timber is cut. In using yield tables to make such forecasts, however, it is necessary to make proper allowance when the mixture of other species differs from that allowed in the yield tables.

Under present conditions yield tables of this character can seldom be used in timber estimating, since they are constructed for dense, second-growth stands which have been uninjured by fire or cattle, and are applicable only to such conditions. The yield of most second-growth stands is much below that of the tables. The tables, however, serve to indicate the large yields which can be obtained by protecting clean-cut land and securing dense, even-aged stands.

Cordwood—Chestnut cordwood is chiefly used for tannic acid extract stock, while a relatively small amount is used for fuel. Consequently the dimensions for wood used in constructing the cordwood yield tables conform to the manufacturers' specifications for the tannic acid extract wood. The wood in Tennessee is used with the bark attached. Split-stem wood is most desired, but a small proportion of round wood is taken to a diameter of three inches if straight and free from large knots. This permits the use of much branch wood and the cutting of trees as small as five inches in diameter. Wood with large knots, as from the crowns of old trees, is rejected by the manufacturers. If trees less than 25 inches in diameter are well handled the tops can be completely worked up, except for the crooked parts of the limbs and the portions having a diameter less than 3 inches.

Table 4 gives the yield in long cords (160 cu. ft.) per acre of chestnut stands at different ages, and of different qualities of growth. In the second column under each quality is given the growth in cords during each decade. The maximum growth in the first quality site takes place during the fifth decade; in the second and third during the sixth decade.

The first and second quality stands contain about 10 per cent of the species other than chestnut, and the third about 15 per cent, which is not included in the tables. In the first and second qualities the associated species are chiefly yellow poplar, red oak and white pine. In the third it is largely chestnut oak, the wood of which to a limited extent is also used for extract stock.

Table 4—Yield of long cords per acre in wood and bark of pure stands of chestnut at various ages on different quality sites. Trees taken to a minimum diameter of 5 inches, and split as required in specifications for tannic extract wood.

Age—Years	First Quality. Yield per acre	First Quality. Growth during preced. decade	Second Quality. Yield per acre	Second Quality. Growth during preced. decade	Third Quality. Yield per acre	Third Quality. Growth during preced. decade
	LONG CORDS.					
15	3.8	....	1.0	....	....	....
20	7.9	7.0	3.9	3.5	....	....
25	12.6	....	7.6	....	3.3	....
30	18.4	10.5	12.0	8.1	6.1	6.0
35	25.3	....	17.1	....	9.1	....
40	33.1	14.7	22.7	10.7	12.3	6.2
45	45.1	....	28.9	....	15.6	....
50	58.4	25.3	36.0	13.3	19.2	6.9
55	70.2	....	43.6	....	22.8	....
60	78.3	19.9	50.4	14.4	26.7	7.5
65	83.1	....	55.5	....	30.8	....
70	86.8	8.5	59.8	9.4	31.6	4.9

Table 5 gives the average annual growth in long cords per acre for stands on different quality sites at various ages. In stands of the first quality the average annual yield of tannic acid cordwood is greatest about the sixtieth year; in those of the second and third qualities, the average annual yield is greatest about the sixty-fifth year. Since the average annual yield is less, both before and after these ages, they represent maturity for cordwood stands, which therefore should be cut at 60 or 65 years, according to site.

Table 5—Average annual yield in long cords per acre of pure stands of chestnut at various ages on different quality sites.

Age of Stand, Years.	YIELD First Quality.	YIELD Second Quality.	YIELD Third Quality.
	LONG CORDS.		
20	0.4	0.2	...
25	0.5	0.3	...
30	0.6	0.4	0.2
35	0.7	0.55	0.3
40	0.8	0.65	0.3
45	1.0	0.6	0.3
50	1.2	0.7	0.4
55	1.3	0.8	0.4
60	1.3	0.84	0.4
65	1.3	0.85	0.47
70	1.2	0.85	0.45

Cordwood stands should be cut clean, except for seedlings or seedling sprouts of sapling size, which can form a part of the succeeding crop. The best quality sites can probably be utilized more profitably for growing larger timber for ties, poles, and sawlogs. The poorer sites can be most advantageously used for cordwood on account of the generally poor growing conditions.

Mixed stands which contain only a small proportion of chestnut cannot be profitably managed exclusively for extract cordwood, unless other species can be cut simultaneously with the chestnut for cordwood, or unless the chestnut occurs in large, pure groups scattered through the forest. This would apply to the larger portion of the mixed oak and chestnut forest of the Highland Rim and farther west. If single, scattered trees of chestnut are cut in such mixed stands there will frequently be insufficient light for the growth of the sprouts, and this would ultimately result in a great decrease in the proportion of chestnut in the forest.

Many second-growth stands on good soils contain a variable proportion of yellow poplar, ash, white pine, and red oak, which are too small to be very valuable for sawtimber at the age when chestnut is best suited for cordwood, or even for ties or poles. Well-formed trees of these species, particularly the ones with slender stems, might be left. They would interfere very little with the reproduction of the chestnut sprouts, and would increase rapidly in diameter. They would make extremely large and valuable sawlogs by the time the next stand of chestnut sprouts was ready to be cut.

Pole Ties—At the present time chestnut ties are not cut extensively in Tennessee, oak timber suitable for ties being still abundant and comparatively cheap. The use of chestnut ties, however, is increasing so rapidly that chestnut can be regarded as a standard tie wood in Tennessee, as it has already become in many States farther north. In Eastern Tennessee chestnut is cut only into pole ties 7 by 9 inches by 8.5 feet long. Since the ties are hewed and the logs are rarely split, there is considerable waste in the larger logs from the lower part of trees more than 16 inches in diameter. There is also a large waste in small trees in the unused length of stem in the top. (See Table 6.) A 7 by 9-inch tie, 8.5 feet long, contains 3.7 cubic feet of solid wood if it is sawed. The hewed ties contain more wood than this, probably as much as 4.5 cubic feet, on an average. Trees which yield ties with the least waste are those from 14 to 16 inches in diameter. In trees below 13 inches, and in those above

18 inches, more than twice the volume called for in the specifications is consumed. In trees below 15 inches in diameter the waste largely lies in the unused upper length of the stem; in trees above 16 inches, the waste is in the diameter in excess of that called for in the specifications.

Table 6—Cubic contents of trees of various diameters, cut to a 4-inch top diameter, average number of ties per tree, and average waste in clear length.

Diameter, breast-high,	Total volume of stem,	Average ties per tree	Actual contents of stem wood to produce each tie*	Total length of clear stem,	Length of clear stem not used,
inches	cubic ft.	No.	Cubic ft.	ft.	feet
10	9.60	1.0	9.6	41	32
11	12.3	1.4	8.8	42	30
12	16.8	2.1	8.0	44	26
13	22.6	3.1	7.3	47	20
14	28.4	4.0	7.1	50	16
15	35.0	5.0	7.0	56	13
16	38.0	5.5	6.9	57	10
17	43.9	6.1	7.2	60	8
18	49.3	6.4	7.7	61	6
19	56.8	6.6	8.6	61	4
20	63.9	6.8	9.4	61	3

Note—*Specifications require four cubic feet.

Table 7 gives the number of pole ties 8.5 feet long by 7 by 9 inches wide, which can be cut from trees of different heights and diameters. The number of oak and locust ties in trees of different diameters are shown in the last column. Both the oak and locust yield fewer ties than chestnut from trees of the same diameter on account of their thicker bark and shorter, more crooked, and more tapering stems. The proportion of oak and locust ties in the stands is less than 33 per cent.

Table 7—Tie volume table, giving average number of pole ties (8.5 feet long by 7 by 9 inches) in trees of different heights and diameters.

	Chestnut.							Oaks and Locust
D. B. H., Inches	Height—Feet.							All Heights
	50	60	70	80	90	100	110	
	Number of Ties Per Tree.							
10	....	0.7	0.9	1.1	1.2	1.2	1.2	....
11	0.8	1.1	1.3	1.5	1.7	1.8	1.9	0.7
12	1.3	1.7	2.0	2.3	2.5	2.7	2.8	1.4
13	1.8	2.3	2.7	3.1	3.5	3.7	3.8	2.0
14	2.3	2.9	3.4	3.9	4.3	4.5	4.7	2.8
15	2.7	3.4	4.1	4.7	5.1	5.4	5.5	3.7
16	2.7	3.5	4.3	5.0	5.6	6.0	6.3	4.0
17	2.8	3.7	4.6	5.4	6.0	6.4	6.6	4.3
18	2.8	3.8	4.8	5.7	6.3	6.7	6.9	5.0
19	2.9	3.9	4.9	5.8	6.5	6.9	7.2	5.3
20	2.9	4.1	5.1	5.9	6.6	7.1	7.4	5.7

The number of ties which can be cut from a stand increases with its age up to a certain limit, after which there is no additional increase, or only a slight one. The greatest annual yield of ties from a first quality site is obtained when the stand is about 60 years old. On second and third quality sites the maximum annual yield is not obtained until the stands are at least 70 years old, because of the longer time required for the trees to reach tie size. By cutting the entire stand clear, a yield of more than 600 No. 1 ties per acre can be obtained from 60-year-old stands of first quality; a yield of 364 ties at the same age from stands of the second quality, and more than 200 ties from stands of the third quality. Table 8 gives the yield of pole ties which can be obtained per acre from unthinned stands of different qualities at different ages. While this table shows the yield which can reasonably be expected from one clear cutting of dense stands, it by no means gives the maximum yield which can be obtained at intervals in two or three cuttings, or from thinned stands.

Table 8—Tie yield table. Yield of pole ties per acre in unthinned stands of chestnut (less than 33 per cent other species) at various ages. (Pole ties 7 by 9 inches by 8.5 feet long).

	Quality I.		Quality II.		Quality III.	
	Total Ties	Average annual yield	Total Ties	Average annual yield	Total Ties	Average annual yield
Years.	Number of Ties.					
25	39	....	....	....	....	....
30	99	3.3	18	....	....	....
35	176	....	60	....	9	....
40	269	6.7	107	2.7	51	1.2
45	359	....	167	....	98	....
50	471	9.4	231	4.6	145	2.9
55	565	....	299	....	184	....
60	619	10.3	364	6.0	217	3.6
65	659	....	406	....	244	....
70	685	9.8	433	6.2	265	3.9

Unthinned second-growth stands should not be cut clean for ties, since the ultimate yield of ties from such a stand can be increased by cutting only trees which have reached a diameter large enough to give a high yield of ties per tree. Cutting in stands within easy hauling distance of a shipping point should not take place until the largest trees are 16 inches in diameter, breast high, at which time all trees of 15 and 16 inches should be removed. Cuttings can be repeated at intervals of a few years, removing each time only the trees of these diameters. This assures an average yield of five ties per tree in quality 1; more than three in quality 2; and nearly three in quality 3. When the third cutting is made it is desirable to cut clean in order to secure an approximately even-aged stand of sprouts. If cutting is continued for too long, not only is the stand converted into an uneven-aged one, but the sprouts from many of the chestnut stumps die on account of the shade, resulting in a large increase in the young stand of oak, maple, beech, sourwood, and other tolerant species which seed abundantly. While the trees removed should be as evenly distributed as their sizes will permit, it is desirable to retain the trees of seedling origin until the last cutting. In making cuttings of this kind great care must be exercised in the last cuttings not to break down the sprouts which have already appeared.

When stands are situated at a distance from transportation facilities, and it is impossible to make several cuttings at short intervals, cuttings need not begin until the largest trees are 17 inches in diameter, and all trees can be cut to a diameter of 13 inches. This would make possible a heavy cutting and still leave a large number of very slender trees less than 13 inches in diameter, most of which would become merchantable within 15 years when the stand could be cut clean.

Young forests of poles, 12 inches or less in diameter, on farms or near a market, should be treated as cordwood stands for extract wood. If correctly done, the thinnings will greatly increase the yield of ties over that given in Table 7, and enable most of the trees to be simultaneously developed to tie size. They can then be removed in two cuttings made at such short intervals as to amount practically to a clean cutting.

Poles—There is a regular market for poles in Tennessee, and this is one of the most profitable forms in which small chestnut timber can be marketed. Poles are best produced in sprout stands in qualities one and two; that is, in the mountain coves and on other soils of good quality. On the poor sites the stems of the trees are apt to be crooked, and have too little taper to meet pole specifications for the larger sizes. Specifications are more easily complied with when the growth is very thrifty. Pole production should be attempted only when logging is easy and transportation by railroads or streams is close at hand. The cost of handling large and long poles is so great that inexperienced contractors frequently fail to make a profit in handling them. Stands intended for poles should be thinned in the manner described for ties. Tall, straight, and sound poles, many of which will have approximately the taper called for in the specifications of the American Telephone and Telegraph Company, can be grown in this way. Table 9 gives the specifications for poles as required by this company. These are approximately the same as required by other users of poles.

Table 9—Specifications for poles. American Telephone and Telegraph Company. Minimum dimensions for peeled poles.

MINIMUM DIMENSIONS OF PEELED POLES.

Length of Poles,	50, 60, 70 or 80-Wire Line Circumf'r'nc		Heavy Trunk Line Circumf'r'nc		Light Trunk Line Circumf'r'nc		Light Line Circumf'r'nc		Branch Line Circumf'r'nc	
	6 ft. from top	6 ft. from butt,	6 ft. from top,	6 ft. from butt,	6 ft. from top,	6 ft. from butt,	6 ft. from top	6 ft. from butt	6 ft. from top,	butt
feet	inchs.	inchs..	inchs..	inchs.	inchs..	inchs	inchs.	inchs..	inchs.	inchs.
20	..	..	..	..	..	..	..	..	15½	23
22	..	..	..	..	..	..	..	..	15½	24
25	..	..	..	..	20	30	20	27	15½	26
30	24	40	22	36	20	33	20	31	15½	29
35	24	43	22	40	20	36	20	35	20	34
40	24	45	22	43	20	40	20	39	20	38
45	24	48	22	47	20	43	20	43	20	42
50	24	51	22	50	20	46	20	46	20	46
55	22	54	22	53	20	49	..	..	..	..
60	22	57	22	56	..	..	..	..	..	..
65	22	60	22	59	..	..	..	..	..	..
70	22	63	22	62	..	..	..	..	..	..
75	22	66	22	65	..	..	..	..	..	..
80	22	70	22	69	..	..	..	..	..	..
85	22	73	22	72	..	..	..	..	..	..
90	22	76	22	75	..	..	..	..	..	..

Sawtimber—Second-growth sprout stands will seldom give any heavier yield of large saw timber than seedlings of the same age, since the rate of growth of sprouts eventually declines and becomes less than that of seedlings. Sprout stands are best suited to the production of smaller stems than those required for the best sawlogs. Sprout timber, however, can very well be sawed into ties, and, in addition to the ties, several boards can be obtained from the larger logs.

Table 10 shows the yield in board feet, both on the basis of the Doyle-Scribner log scale and on the basis of the actual mill cut, which can be obtained from stands of different qualities at different ages. It also gives the supplemental yield in cords of extract wood from tops and from trees below 10 inches in diameter, and the total value of the stands at different ages. These tables are based on 132 sample plots.

QUALITY I.

Table 10(*a*)—Total yield and value of stands of chestnut in board feet and cords at different ages.

Age Years	Yield Per Acre of Trees 10 Inches and Over.		Yield of trees from 5 in. to 10 in. and tops of trees 10 in. and over.	Value per acre at $2 a thousand board ft. and $1 a cord.
	Doyle-Scribner, Board feet	Actual cut, Board feet	Long cords	Dollars
25	900	2,000	16.0	20.00
30	2,100	4,500	15.3	24.30
35	3,800	7,600	13.5	28.70
40	5,800	10,900	12.3	33.10
45	8,300	14,900	11.0	40.80
50	11,100	19,300	9.5	46.10
55	14,400	24.300	8.0	56.80
60	18,100	29,900	7.0	66.80

QUALITY II.

Table 10(*b*)—Total yield and value of stands of chestnut in board feet and cords at different ages.

Age Years	Yield Per Acre of Trees 10 Inches and Over.		Yield of trees from 5 in. to 10 in. and tops of trees 10 in. and over.	Value per acre at $2 a thousand board ft. and $1 a cord.
	Doyle-Scribner, Board feet	Actual cut, Board feet	Long cords	Dollars
30	200	500	17.3	18.30
35	1,200	2,600	16.5	21.70
40	2,300	4,800	15.5	25.10
45	3,700	7,400	14.0	28.80
50	5,400	10,200	13.0	33.40
55	7,300	13,300	11.5	38.10
60	9,400	16,700	10.0	43.40

QUALITY III.

Table 10(*c*)—Total yield and value of stands of chestnut in board feet and cords at different ages.

Age Years	Yield Per Acre of Trees 10 Inches and Over.		Yield of trees from 5 in. to 10 in. and tops of trees 10 in. and over.	Value per acre at $2 a thousand board ft and $1 a cord
	Doyle-Scribner, Board feet	Actual cut, Board feet	Long cords	Dollars
40	400	1,000	17.5	19.50
45	1,300	2.800	18.0	23.60
50	2,400	4,900	17.0	26.80
55	3,600	7,200	15.3	29.90
60	5,000	9,600	13.5	32.70

RELATION OF BOARD FEET TO CUBIC FEET AND CORDS.

Table 11 shows the number of board feet (scaled by the Doyle-Scribner rule) to 1 cubic foot and to 1 cord of merchantable volume for trees of different diameters. It is evident from this table that as the diameters of the trees increase a greater number of board feet can be obtained for every cubic foot and consequently for every cord of merchantable volume. Thus, only 3 board feet can be obtained per cubic foot for trees 12 inches in diameter, while from trees 30 inches in diameter 5.2 board feet can be obtained for every cubic foot. In addition the lumber from the larger trees is of better quality than from the smaller ones. This means that, in many instances, it is more profitable to convert the smaller trees into extract wood than into lumber. For instance, if the stumpage price of lumber is $2 per thousand board feet and of extract wood $1 per cord, the same amount of material from 12-inch trees would be worth $1 if sold as extract wood and 63 cents if sold as lumber. On the other hand, from 30-inch trees the same amount of material would be worth $1 if sold as extract wood and $1.11 if sold as lumber. At these stumpage prices the timber is worth more as extract wood from trees up to 24 inches in diameter, and more as lumber from larger trees. If the actual mill cut, which overruns the values given by the Doyle-Scribner rule, were used as a basis, the number of board feet per cord would be greater, and the value of the trees for lumber correspondingly increased. In these calculations the slabs from the saw logs are given no value, and tops, which would not be merchantable as sawlogs, are excluded.

Table 11—Board feet (Doyle-Scribner rule) per cubic foot and per cord for trees of different diameters.

Diameter, breast-high.	Board feet per cubic foot of merchantable volume.	Board feet per cord of merchantable volume.	Value of a cord at $2 per thousand board ft.
Inches	Board feet	Board feet	Dollars
12	3.0	313	$0.63
13	3.1	322	0.64
14	3.2	333	0.67
15	3.4	342	0.68
16	3.5	364	0.73
17	3.6	376	0.75
18	3.8	386	0.77
19	4.0	407	0.81
20	4.2	429	0.86
21	4.3	448	0.90
22	4.4	461	0.92
23	4.6	472	0.94
24	4.8	493	0.99
25	4.9	515	1.03
26	5.0	526	1.05
27	5.0	535	1.07
28	5.1	538	1.08
29	5.2	546	1.09
30	5.2	556	1.11

SUMMARY.

Chestnut is one of the most widely distributed trees of Tennessee, and the most important tree in the mountains of the eastern portion of the State; occupying large areas of land which have a low agricultural value.

The great number of uses to which the wood is put enables extremely close utilization not only of all portions of sound trees, including limbs and bark, but also a large amount of more or less defective wood. Small trees are used for poles, posts, and ties; large, sound trees for lumber and shingles. Tops and low-grade wood are used for tannic extract, fuel wood, and paper pulp stock.

Chestnut is not only a tree of rapid growth, but reproduces easily from seed and vigorous and abundant sprouts even from large old stumps. It forms pure stands or large, pure groups over extensive areas, permitting cheap utilization, and makes heavy yields at an early age. Under average conditions of growth, yields of 40 cords of tannic acid extract wood; or more than 300 No. 1 (7-in. by 9-in. by 8.5-ft.) ties; or 90 large poles; or 10,000 board feet of lumber, can be obtained per acre within 50 years from unthinned but protected second-growth stands. When logged for poles, lumber, or ties, about 13 cords of extract wood can also be obtained. If the stands are thinned, the yield can probably be doubled in the same time. For these reasons chestnut is one of the most promising trees for forest management.

To obtain the best yields from chestnut stands, protection from fire is absolutely necessary, because the trees, and particularly the young trees, are extremely sensitive to fire injury. It is also necessary to protect young stands from cattle, since considerable damage results from browsing the foliage and young shoots.

In order to develop the maximum producing value of the forest, different methods of cutting should be used in different types and classes of forest. Large sawtimber should be grown only in the coves and on other good situations. Inaccessible old stands which can be used only for lumber should be cut to a relatively low diameter limit (16 inches), the large, unsound trees being left for possible future cutting for extract wood and for seed trees, and the smaller trees for increase in growth. Seedling stands are desirable and would be encouraged by this method of cutting. When extract wood can be sold, old stands on good soils should be cut to about the same diameter limit, if the production of sawtimber is the chief object of management, but all of the large, old defective trees should be removed for extract wood. On the ridges old timber should be cut for extract wood to a diameter of 8 or 10 inches, with the object of obtaining even-aged sprout stands which on such sites will give in a short rotation a higher yield than seedling stands, because of the more rapid growth of sprouts than seedlings when young. When there is no market for extract wood, and only sawtimber can be exploited, chestnut on the ridges can be cut to a diameter of 14 inches breast high, which would permit a second profitable cutting to be made within 15 years.

Even-aged, second-growth sprout and seedling stands, such as occur on farms, and on old charcoal cuttings, should be cut clean in not more than three cuttings, made at intervals of from 5 to 10 years, in order to replace the stands by even-aged sprout stands. The yield of such stands, in ties, poles, and lumber, and even in cordwood, can be greatly increased by thinning the stands while young, at regular intervals, removing the large crooked and forked trees, and the tall, slender trees with narrow or one-sided crowns, and leaving the larger best-formed trees for the mature stand.

3

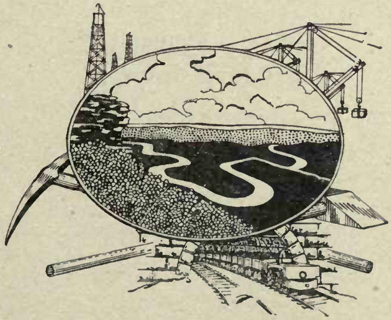
STATE OF TENNESSEE
STATE GEOLOGICAL SURVEY
GEORGE H. ASHLEY, STATE GEOLOGIST
SUCCEEDED BY
A. H. PURDUE

IN CO-OPERATION WITH THE
FOREST SERVICE
U. S. DEPARTMENT OF AGRICULTURE
HENRY S. GRAVES, FORESTER

BULLETIN 10-C

YELLOW POPLAR IN TENNESSEE

BY
W. W. ASHE
FOREST EXAMINER, U. S. FOREST SERVICE



NASHVILLE, TENNESSEE
1913

WILLIAMS PRINTING COMPANY, NASHVILLE

STATE GEOLOGICAL COMMISSION.

GOVERNOR BEN W. HOOPER, *Chairman.*

DR. BROWN AYRES, *Secretary,*
President University of Tennessee.

CAPT. T. F. PECK,
Commissioner of Agriculture.

DR. J. H. KIRKLAND,
Chancellor Vanderbilt University.

DR. WM. B. HALL,
Vice-Chancellor University of the South.

GEO. E. SYLVESTER,
Chief Mine Inspector.

A. H. PURDUE,
State Geologist.

TABLE OF CONTENTS

Page
Commercial outlook 5
Distribution 7
Forest characteristics 8
  Form of stem and root system 8

Silvical characteristics 10
  Soil and moisture requirements 10
  Temperature and light 10
  Reproduction 11
  Diseases and defects 11
  Sensitiveness to fire 11
  Other injurious agencies 12
  Properties and uses of wood 13

Growth 17
  Yield 23
  Graded volume tables 24
  Increase in value with size 28
  Increase in price 29

Increasing the yield from timber land 30
  Management 31
    Developing a desirable form of stand 31
    Sprout forms 31
    High forest forms 32

  Maturity of timber 36
    Single trees in mixed stands 36
    Determination of future yield from future stands 38
    Pure stands 41

  General instructions 44
    Protection 44
    Elimination cuttings 45
    Thinnings 45

  Better utilization 48
    Reduction of waste 48
    Selling timber in the most profitable form 49

Plantations 51

Cost of growing 55
    Soil value 55
    Cost of planting 55
    Yield 55
    Interest rate 55
    Protection 55
    Taxes 56

PREFATORY STATEMENT

The study upon which this report is based was undertaken by the State Geological Survey in coöperation with the Forest Service, the work being done under the office of State Coöperation in the Forest Service, and under the local instruction of the State Geologist of Tennessee. By the terms of the coöperative agreement the state is authorized to publish the findings of the investigation. At the time arrangements for the work were made, George H. Ashley was State Geologist, but he subsequently resigned and was succeeded by A. H. Purdue.

CORRECTIONS

Page 5. Line 4 from top read: "69,612,000" in place of "69,612."

Line 5 from top read: "1,567,000,000" in place of "1,567,000."

Page 16. Line 2 from bottom read: ".23 per cent." in place of "23 per cent."

Page 17. Line 6 from bottom read: "different" in place of "difficult."

Page 29. Line 13 from top read: "The values" in place of "The value."

Page 30. Following heading of the table read: "*Estimated.*"

Page 32. Line 18 from top read: "The advantages" in place of "The advantage."

Page 36. Line 14 from top read: "5 per cent. a year" in place of "5 per cent."

Page 54. In footnote insert: "Table 20."

Page 55. Lines 25 and 26 read: "thinned stands" (page 17) in place of "thinning stands."

(NOW is the best time to make the corrections.)

Slyph

YELLOW POPLAR IN TENNESSEE.

By W. W. Ashe.

COMMERCIAL OUTLOOK.

On the basis of the present cut of lumber, yellow poplar* ranks as the second tree in importance in Tennessee. In 1912 there were 378,747,000 board feet of oak sawed in Tennessee; 107,265,000 board feet of yellow poplar; and 69,612,000 board feet of red or sweet gum. The total cut of lumber in the state was 1,567,000,000 board feet. The total cut of yellow poplar in the United States was 623,287,000 board feet. The value of the cut of 1912 is not yet available from the census returns. Oak leads, with a cut during the year 1911 of 382,000,000 feet board measure, valued at $7,790,000, followed by yellow poplar with a cut of 119,000,000 feet board measure, valued at $3,360,000. Chestnut and red gum each had about one-half the cut of yellow poplar, but the output of each was only about one-third as valuable. The average value of oak lumber in 1911 at the mills in Tennessee was $20.68 per 1,000 feet board measure; poplar $28.22; red gum $12.33, and chestnut $16.91.

In 1906 the cut of yellow poplar in Tennessee was 110,480,000 board feet, the state contributing 19 per cent. of the total cut of yellow poplar in the United States.

In 1907 the cut was 137,900,000 feet board measure, being 16 per cent. of the total cut of the United States, the average price of yellow poplar lumber in Tennessee being $24 per 1,000 board feet.

In 1910 the cut was 138,705,000 board feet, 19 per cent. of the total cut of this species in the United States, the average price of its lumber in Tennessee being $28.10 per 1,000 board feet.

In 1911 it was 119,000,000 board feet, about 19 per cent. of the total cut of the United States. In 1912 the cut declined to 107,265,000 board feet, 17 per cent. of the total cut of the United States.

Many lumber companies that were interviewed in Tennessee report from 15 to 20 years supply of yellow poplar timber. On the basis of 20 years' supply the total stand of old yellow poplar timber in Tennessee is about 2,500,000,000 board feet.

The highest production of yellow poplar lumber in Tennessee was doubtless obtained between 1907 and 1910. Since 1910 the output from Tennessee has declined from 138,000,000 board feet to 107,000,000 board

---

*Botanically, yellow poplar is known as *Liriodendron tulipifera L.* The tree is also known as tulip tree and whitewood.

feet. While this decline in cut will continue for some time it is possible, by protecting and managing the young growth, to have it replace the old timber, and in this manner to maintain a continuous, though undoubtedly reduced, output of this valuable lumber.

The greater and more valuable portion of the cut of yellow poplar is the product of old timber. In order that the lumber may average $28 per 1,000 board feet, the trees from which this lumber is sawed must have, at present prices of lumber, an average diameter of 27 inches, breast-high. Although the amount of young timber which is cut for commercial purposes is small, it has a standard and rapidly increasing value for saw timber. With the continued reduction in the supply of old timber, the second growth must become the chief source of future supply. And consequently it is extremely important to know something of the amount of young growth and its probable future price. It is also desirable to know the rate of growth of the young timber, the possible profit in growing it, and the best methods of management for accelerating its growth and increasing its value.

The results of an investigation in Tennessee show that yellow poplar has a comparatively rapid rate of growth while young; it seeds abundantly and reproduces freely on suitable sites, forming either pure groups or a considerable proportion of mixed seedling stands. On account of its soft, white wood, which is very free from large knots, it is merchantable even when of small diameter, while on account of its straight stem with only moderate taper it yields under the saw as large a proportion of lumber per cubic feet of total volume as do the pines. On account of its intolerance of shade its yield per acre is less than that of chestnut and some of the pines, but this is offset by the rapid growth of the individual tree and its vigorous response to thinnings. On the whole, no other species of tree which has a wide distribution in Tennessee offers such excellent inducements for the protection of small trees, and even for propagation and planting. Not only is there an assured and remunerative market for the timber of small sized trees but its rate of growth is so rapid that returns are obtained at an early period for a forest tree. Second growth trees are largely "sapwood" or "white poplar," but there is now no discrimination against lumber from this grade of timber, and the clear sap lumber at present commands a higher price than the best yellow heartwood did 20 years ago.

Yellow poplar is also extensively used in Tennessee for wood pulp for the manufacture of paper. While some wood from the limbs of large trees which are cut for saw timber goes into this product the greater portion of it comes from young trees of pole size the white wood of which renders such trees very desirable.

It is also extensively employed for veneers for baskets and crates and for excelsior.

DISTRIBUTION.

Yellow poplar is commercially important throughout Tennessee. It is most abundant on the limestone valley lands of the great basin and in the valley of East Tennessee; in the coves and hollows of the Cumberland Mountains; and in the lower coves of the Unaka and Smoky mountain ranges; but it nevertheless reaches a large size in such counties of West Tennessee as Obion, Dyer, and others which lie west of the barrens. Above 3,500 feet elevation in the Unaka and Smoky mountains it occurs only irregularly. It is very largely absent from the thin soiled summit of the Cumberland Mountains, from the drier portions of the shale and sandstone ridges and from the barrens. Even when most abundant it seldom forms numerically as much as 10 per cent. of the forest over more than a few acres, but on account of the large size of the trees it frequently contributes from 20 to 25 per cent. of the merchantable timber in the bottoms and on the lower slopes, and may form 50 per cent. of the value of stand. The yield of poplar lumber seldom amounts to as much as 500 board feet per acre over a large tract, and frequently is less than 200 feet per acre.

The following table shows the number of trees of different diameters per acre in Tennessee on a large tract which has been examined by the Forest Service. If this tract represents average conditions of the hardwood forest of Middle and Eastern Tennessee, there is sufficient young poplar in the stands to assure a large future cut of timber, provided the young trees are not cut before they reach the size of maturity for saw timber.

Number of trees of yellow poplar per acre on an unlumbered tract.

Diameter Inches Breast-high	Scott and Anderson counties (Cumberland Mt.)
Under 12	4.
13-20	1.3
21-30	1.3
Over 30	.1

On cut-over and closely culled land which has not been badly burned, there is as a rule a large number of small poplar trees in the coves and hollows. These trees have sprung up in the openings which were made in logging. Occasionally they form a continuous stand in the narrow mountain valleys or form groups, pure or nearly pure, from a square rod to several rods in extent. There is often a far larger proportion of poplar numerically in young stands on cut-over land than there was in the original forest. This young timber will constitute a very important element in the yellow poplar supply of the future. On the other hand on forest lands from which the old yellow poplars were removed before any of the other hard woods were cut, there is usually a poor replacement of young yellow poplar. There was not enough light for the establishment of yellow poplar, and seedlings of other species which are more tolerant of shade, occupied the space from which the yellow poplar was cut. Where tracts have been badly burned, the young yellow poplar has been largely killed.

In farmers' wood lots there is as a rule a large amount of young poplar except where the pasturage of cattle has suppressed the young trees, which is the case on many farms. There are, however, many pure stands of young yellow poplar of sapling and pole size, on farms which have sprung up in old pastures that were under fence so that cattle were excluded. While the total acreage of these stands is not large, they can be made where they occur, extremely valuable, if given proper management.

There is likewise a considerable acreage of second growth timber in old coalings. While these stands are largely formed of chestnut and oak sprouts, they generally contain, in the coves and hollows, a larger percentage of yellow poplar than the original forest.

While there is undoubtedly an excellent representation throughout Tennessee, of sapling and small pole-sized yellow poplar in second growth, there is a deficiency of large pole-sized trees which might become merchantable as large saw timber, during the next 20 to 25 years.

Notwithstanding the generally excellent representation of young growth yellow poplar, the future supply of this timber is threatened by the inroads which are being made on the young growth, by cutting it before it is mature, for paper-pulp stock and box-board bolts.

FOREST CHARACTERISTICS.

Form of stem and root system.—Mature poplar trees attain large sizes. It is one of the largest, if not the largest, species occurring in Tennessee. In diameter it may occasionally be surpassed by the sycamore, and in height by the cottonwood and hemlock (spruce pine), but none of these equals yellow poplar in both dimensions. Individual trees in Tennessee have been measured which had total heights of more than 140 feet, and diameters measured above the root swelling of more than 60 inches; while heights of more than 150 feet and diameters exceeding 75 inches have been recorded, but not in the same tree. The length of stem free of branches of mature trees varies from 50 to 75 feet. The crown generally occupies from 40 to 50 per cent. of the total height. The stem is column-lar, tapering very slightly, and is very free from crooks and forks. About the middle of the crown, the stem divides into branches and its identity is lost. The lower branches die off rapidly until the full length of the stem is formed, and the scars which are left by them heal quickly and smoothly. This is one of the most valuable characteristics of the tree. Water sprouts occasionally appear on the trunks of trees exposed to sunlight, but the stems are never injured by the growth of such sprouts, as is the case with white oak.

While the stem of the old trees usually forks within the crown, young trees, particularly those in even-aged crowded stands, as a rule have

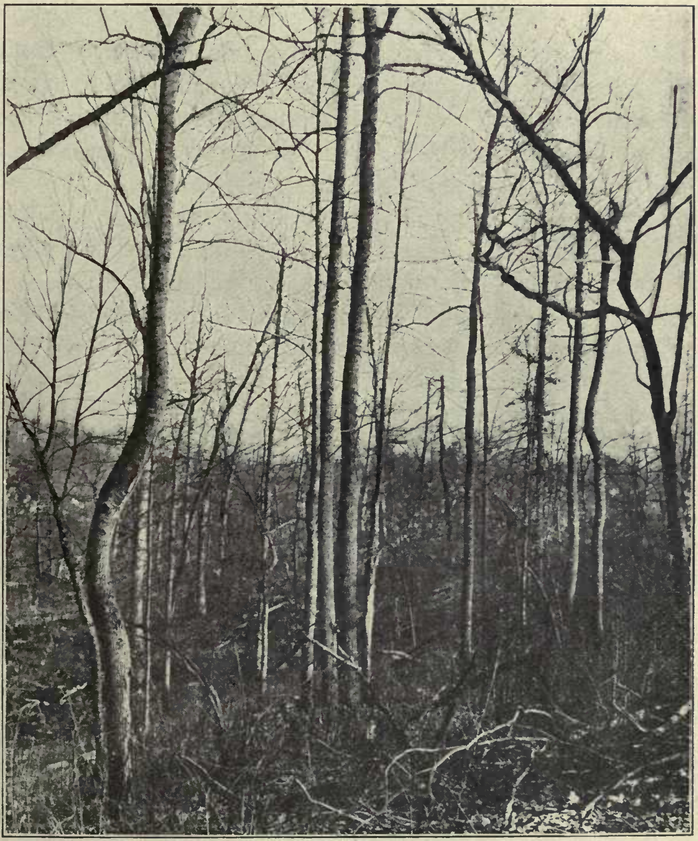


FIG. 1. Trees of yellow poplar which have been isolated in a second-growth stand by the removal of the chestnut and red oak. As a result of the isolation these trees are in condition to make rapid diameter growth. Since there is no undergrowth the restocking should be largely formed of poplar. (Photo Forest Service.)

straight undivided stems to the very top of the crown. Since the branches on them are small, logs which lie within the crowns of young trees are suitable on account of their straightness both for sawlogs and for pulpwood. This character which permits the close utilization of young trees, adds to their value.

The seedling yellow poplar has a long, straight taproot, which bears only a few fleshy rootlets. The taproot interferes with transplanting. Seedlings when transplanted do not readily establish themselves on account of the few rootlets.

Old trees have a very deep-seated and strong root system which renders them windfirm.

SILVICAL CHARACTERISTICS.

Soil and moisture requirements.—Yellow poplar requires for its best growth a deep, fertile and moist, but well drained, soil. It has a strong preference for soils which are derived from limestone, although it is common on other fertile soils which are rich in humus. It makes very slow growth and reaches only a small size, however, on either wet or extremely dry soils. The most congenial sites for it are the lower slopes and hollows of the mountains, and the soils of the rolling limestone valleys which are well drained through the underlying fissured rock. The soils occupied by yellow poplar are usually of high agricultural value for the growing of grain and grass, and, consequently when not too steep have been largely cleared and placed in cultivation. The chief remaining areas of considerable size which contain merchantable yellow poplar and which are best suited for its growth are the hollows along the Cumberland Mountain, the lower slopes and coves of the Smoky and Unaka range, and the hollows of the intervening ridges. The small tracts of forest which yet remain on the farms of the limestone valleys frequently contain considerable old poplar, and on many tracts a large amount of young timber, and are well suited for its growth.

Temperature and light.—In spite of its exacting requirements respecting soil moisture, yellow poplar demands considerable warmth. It grows well from the lowest elevations in Tennessee up to altitudes of 3,000 feet on the north slopes of the Unaka and Smoky mountains, but it becomes sporadic on north aspects above this altitude. It demands a large amount of direct sunlight for its best growth, at all ages after it is thoroughly established.

The seedling and young tree will endure considerable side shade, more on moist than on dry soils, but if the overhead shade is too dense or is prolonged, the tree dies. A very light overhead shade or a side shade is beneficial to seedlings until they are two years old, by which time they should be well established. On account of its intolerance of shade the stem clears itself of branches thoroughly when the trees are crowded.

Reproduction.—Yellow poplar reproduces chiefly by means of seed. It reproduces to a limited extent by means of sprouts but only from small trees until they reach the size of poles; the sprouting of old trees is unreliable. Sprouting is best in full sunlight. The sprouts from trees which are shaded are weak. The seeds, which are borne in small cones, are about one inch long, including the slender wing, and are so light that they may be blown several hundred yards from the parent tree. The seeds from the top of the cone and from the exterior will not germinate. These are the last to fall from the tree, often remaining until the following spring, and in collecting seed for planting they should be discarded. Trees begin to bear fertile seed when about 40 years old. Seeds are produced on older trees in great abundance and almost annually, but a large proportion, as a rule about 90 per cent., are infertile. They ripen in September and October and are in great part distributed at once by the wind. They largely germinate during the following spring and the early part of the summer, but some seem to lie over on the ground until the second spring. Germination takes place wherever the soil is moist, and the seedlings easily establish themselves, but they fail to survive the dry periods of the first summer unless on a moist or shady site. Stocking, consequently, is better on north slopes, in coves and hollows or in lower slopes, than on the drier upper slopes and on southern exposures. It is also best where the mineral soil has been exposed, as in old fields or where the soil has been upturned by logging or by hogs. A thick layer of dry leaves is unfavorable.

Diseases and defects.—While old trees of yellow poplar have many defects, such as wind-shake, frost crack, and stained wood, there are, so far as known, no destructive fungous diseases or insects which attack and kill trees.

Sensitiveness to fire.—Seedlings and small trees of yellow poplar are extremely sensitive to fire, being more easily injured even than chestnut. This is due primarily to the thin and smooth bark of the young tree of yellow poplar. An additional reason for their great injury is that the sap and inner bark of yellow poplar become active earlier than in the associated trees. This greatly exposes this species to early spring fires, which, when they take place during dry and windy periods before the forest foliage is out, are very hot and destructive. Fortunately yellow poplar is somewhat protected by being largely confined to the damp hollows and coves. Seedlings of yellow poplar which are killed down by fire will usually sprout from the root, unless they are shaded. This power, however, is feeble when compared with that of many other broad-leaf species with which it is associated, particularly with that of chestnut, because after a small poplar has been killed down by fire a few times, the root generally dies. Old trees of yellow poplar are protected by their thick bark, and are rarely killed outright. However, many old trees on dry sites have butt hollows, which open on their upper side and which resulted from fire.

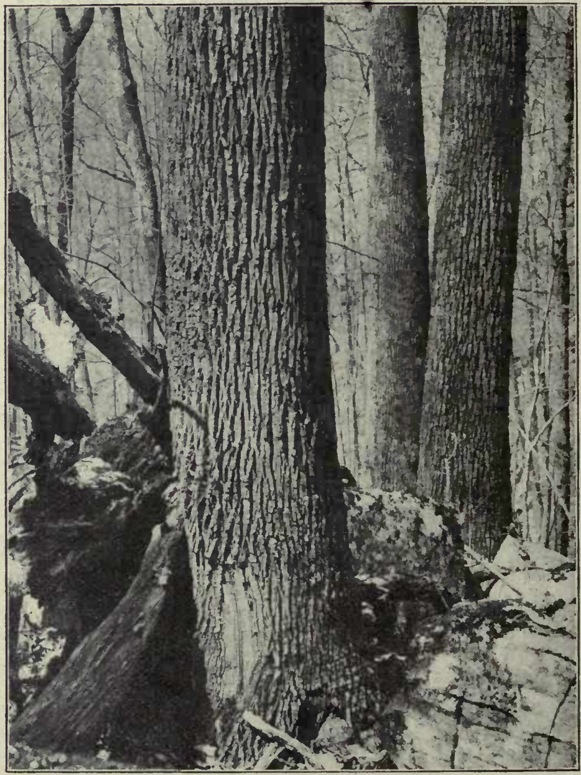


FIG 2. A group of yellow poplars which are growing on a rocky slope and which have been injured at the butts by fire. Note the hollow on the left of the base of the large tree and the scar to the right of the hollow, both caused by fire.

Other injurious agencies.—The tender shoots and leaves of small yellow poplars are freely eaten by cattle and sheep. For this reason stock should not be grazed on areas which are in process of stocking until the small trees become 8 to 10 feet in height. Hogs do not eat yellow poplar roots. They dig up seedlings, however, while rooting for other food on fertile slopes and coves. The leader of yellow poplar is rarely broken by sleet. Both old and young trees are very windfirm.

Properties and uses of the wood.—The wood of yellow poplar is soft, light, stiff, and rather brittle, but close-grained. The heartwood varies in color from nearly white to a yellowish brown; the sapwood is white. The heartwood shows only a slight tendency to warp and shrink, and is durable when exposed to the weather, but only moderately so in contact with the soil. The sapwood is much less durable than the heartwood when exposed; and shrinks, warps and checks more, but if carefully kiln-dried the tendency to these defects is reduced. Air-dried, the wood has a specific gravity of .42 and weighs from 26 to 28 pounds* per cubic foot. Rough, kiln-dried lumber weighs about 2,800 pounds to the 1,000 board feet, but the green wood is much heavier. While slightly heavier than white pine, poplar has about the same relative strength (Modulus of elasticity 1,716,000; modulus of rupture, 10,850)†, and is consequently adapted to nearly the same uses. It withstands end-compression well, has high shearing strength and abrades quite even and slowly. While it does not split easily, the fracture is straight and clean.

In the center of thrifty second-growth trees there are frequently as few as three rings of annual growth to an inch of radius; while the periphery of young trees, stimulated to growth by isolation, may be equally as coarse-grained. In old trees, twelve rings per inch of radius is usual, and commercial timber will generally show from ten to fifteen rings per inch. There is a little difference in density between the early and late wood in the annual band. The numerous pores are small and uniformly distributed through both early and late wood of the annual band. The pith rays or medullary rays are of uniform size, nearly invisible to the naked eye, and scarcely raised when the wood is split radially. While the grain of the wood is as a rule extremely straight, it is occasionally wavy or curly, a characteristic which is usually limited to one face or one side of a tree. Occasionally trees are burly or bird's eyed.

The proportion of heartwood varies with age, and is much greater in old trees. It begins to form at from fifteen to thirty-five years of age, earlier on good than on poor sites. Its formation, however, does not continue regularly and at the same rate as the growth of the tree, but more slowly, since a tree seventy-five years old will usually have more than forty rings of sapwood. Young trees on average soils which are fifty years old or less, are for this reason largely sapwood and have only a small core of heartwood. In young trees this large proportion of sapwood has retarded their use for lumber to a considerable extent. Young, thrifty sap trees are called "hickory poplar," on account of the toughness of their wood.

---

*Sargent, Tenth Census.

†Tests by Branch of Products, U. S. Forest Service.

Soil and moisture conditions cause a considerable variation in the amount and color of heartwood and the percentage of moisture in the wood. Trees growing on uniformly moist but well-drained soils (well aerated), such as fertile coves and best limestone soils have a thin sapwood, heartwood, dark brownish-yellow or canary yellow in color, containing a low percentage of moisture and the lumber from such trees consequently is not so subject to shrinking, checking, or warping. Large old trees on such sites, as a rule, have less than one inch of radial sapwood. Second growth trees on similar sites, 12 inches in diameter and sixty years old, often have less than 1.5 inches of sapwood on the radius. On the other hand, on dry soils, the trees have a small, pale yellow or nearly white heartwood ("white" or blue poplar") and a very thick sapwood. Such dry soils may be either physically dry as in the case of coarse sands, fissured slates or very fine grained clay, when the water table is low or fluctuates, or physiologically dry, as in the case of such sour soils as are poorly drained, because of deficient aeration. On "dry" sites the sapwood which acts as a water reservoir is sometimes so thick as to include one-half the radius of a tree two feet in diameter. The wood of "white poplar" and "blue poplar" has a high percentage of moisture and is subject to shrinking, checking, and warping, but is tougher than that which is deep yellow. Trees with pale-colored heartwood are most subject to windshake and discolored (calico) wood. The canary yellow wood is most prized for general uses.

The lumber can be easily and quickly kiln-dried. The best results in commercial kiln drying are obtained by first subjecting the wood to live steam or to hot moist air which is subsequently replaced by a free circulation of warm dryer air; but the wood is not refractory when a dry chamber system is employed, and is not prone to case harden and check. Sapwood blues if piled closely. This can be prevented by immersing the timber in a 10 per cent. solution of bicarbonate of soda. Air drying, though slow, is effective. The wood is easily impregnated with preservatives, either with copper sulphate by the gravity process or with creosote or zinc chloride.*

The wood has other qualities which give it a very wide range of usefulness. It works easily and smoothly when dried, that from any one tree being comparatively uniform in quality and as a rule that from trees in one locality is very uniform in character. It absorbs stain easily, but on account of its dull uniform texture it seldom shows a handsomely grained surface. It is too soft to retain a high polish on untreated wood, but it takes paint well and if the paint is highly glossed, it holds the gloss indefinitely. The knots, which are small and infrequent, even in the case of small trees, except in lumber cut from the crown, are usually light colored and tight, plane smoothly and also take and hold paint well. For doors, paneling, vehicle bodies, especially for automobiles and office and church furniture, the wood is especially desirable. It holds glue strongly, and is desirable as a backing for costly veneers. The heartwood of trees with the deep yellow-colored wood, while not as durable in contact with the soil as that of many conifers, has been extensively employed for water pipes, wooden pumps, and outside steps. Such wood is durable on exposure to the weather—as for weather boarding, shingles, fencing, dugout boats, and troughs—and was largely employed in Tennessee for these uses until its scarcity and high price required the substitution of cheaper woods. On the other hand, the sapwood of yellow-hearted trees and the entire wood of the "white poplar" are not durable if subject to the weather. Other uses of the wood are for the manufacture of packing boxes, printers' materials, especially type cases, drawers, domestic and culinary woodenware. Among such articles which are made in Tennessee are dough bowls for bakers, which are turned in sizes up to four feet in diameter from one piece of wood. It is extensively employed in the manufacture of toys, cheap furniture, and interior woodwork. It is used in the form of veneer for baskets and crates. For the grape trade, which demands a white wood basket, the sapwood is used or the heartwood is bleached with sulphur.

---

*Branch of Products, U. S. Forest Service.

A large amount of rotary-cut veneer is also produced in Tennessee for use in the manufacture of furniture, for built up stock, for packing boxes and trunks. Small and low grade logs are made into excelsior, wood fiber and ground wood; while slabs, veneer cores, small trees and limb wood of large trees are also used for paper pulp,* being reduced by the soda process and forming a close-felting and easily bleached fiber. Extra wide boards, twelve to thirty inches, cut in thin stock and cleated or bound in bundles, are largely exported from Tennessee to Europe and South America, where they are used for paneling and for vehicle bodies, but the timber is also exported in the squared log. The quarter-sawed lumber, which is manufactured in considerable amount, especially in wide widths, does not warp and is consequently more desirable than flat sawed lumber as a backing for veneers, for wide paneling and for vehicle bodies.

---

*The Columbia Paper Company, of Bristol, is the largest user of poplar pulpwood in Tennessee.

The wood also enters largely into the construction of piano cases and other musical instruments. On account of lack of odor it is a desirable wood for cases for dairy goods, such as cheese boxes and butter tubs, and for cracker boxes and candy pails. It is extensively used in the manufacture of cigar boxes, either as a core for Spanish cedar veneer, or simply stained and printed in imitation of it. It is employed for bobbins and yarn spools, and in the manufacture of refrigerators, boats, and car finish. While the heartwood of old trees is preferred for most of these uses, the sapwood is being less discriminated against when well kiln-dried, and eventually must be largely used instead of the heartwood. To a great extent cheaper woods, like gum and tupelo, are replacing it for headings, for slack cooperage stock, for pumps, for cheap packing cases and for tobacco hogsheads. But it is still a standard wood for small packing boxes of the lock-end type, such as are largely used for drugs, as it shows for this use a greater strength for its weight than any other competing wood.* The white sapwood which admits of direct printing is preferable for this use. It is being substituted for white pine in making staves for fish kits and pails, patterns for castings, drawing boards and engineer's tables, and for pontoon bridge timbers, uses which demand clear boards. On the other hand it has been in part replaced by cheaper materials, such as gum and cottonwood in agricultural implements; by cottonwood and sap pine for wagon bodies, and by pine for exterior construction work.

On account of its great shearing strength, its capacity for withstanding end compression and the straightness of its stem, yellow poplar poles are well suited for mine props. In temporary workings (robbings) second growth sap timber can be used untreated, but where durability is essential the timber should be impregnated with a preservative. Treated wood is also adaptable for use as poles and fence posts. This adds greatly to the usefulness of the second-growth timber. It is well adapted for match sticks on account of the straightness of its grain, the ease with which the wood ignites, its free burning resulting in a steady flame, and the completeness of combustion. It has been used for this purpose, however, only to a limited extent.

The wood burns well and quietly, the embers glowing for a long while in still air. The fuel value of the wood compared with that of hickory, is low. The amount of ash is small, .23 per cent.† It makes a light charcoal which is held in low esteem.

---

*Tests of the woods used in the box trade made by Branch of Products, U. S. Forest Service, show that for its weight yellow poplar has the highest shearing and cross breaking strength. Cottonwood ranks next to it

†Sargent, Tenth Census.

GROWTH

The possibility of profitable management of yellow poplar largely depends upon the rate of growth of the young trees, both as individual trees in mixed stands and when in pure groups or pure stands. Table 1 gives the rate of growth of young trees in mixed stands, and of the dominant trees in irregularly thinned stands in height, diameter, volume in board feet, circular sawed ¼-inch kerf, cubic feet of wood only without bark, and cords of 160 cubic feet of peeled wood, measured after it is stacked and dry. The peeled cordwood is measured as required for paper-pulp stock.

TABLE 1.—*Rate of growth of young trees of yellow poplar.*

	Scattered trees in the mixed forest					Dominant trees in pure, even-aged, thinned groups	
Age of trees	Height	Diameter breast-high	Volume saw cut ¼ in. kerf	Volume wood without bark		Diameter breast-high	Volume saw cut ¼ in. kerf
Years	Feet	Inches	Bd. ft.	Cubic ft.	Cords of 160 ft.	Inches	Bd. ft.
20.......	40	4.6	...	2.2	.02	5.7	
30.......	61	7.7	44	7.6	.07	8.5	54
40.......	78	10.5	111	22.	.19	11.1	121
50.......	87	12.8	177	29.2	.20	13.7	200
60.......	94	14.7	241	42.1	.38	16.1	286

The rate of growth of single young trees in the mixed hardwood forest is slower than that of the larger or dominant trees in pure even-aged groups which occur in cut-over land and in old fields. This is largely due to the fuller light conditions under which the pure even-aged groups grow. The narrow crowned intermediate trees in the pure stands, whose tops do not enjoy full sunlight, have nearly the same rate of growth as the scattered trees in the mixed, many-aged forest. It is believed that by systematically thinning young stands, an average diameter of 20 inches, breast high, can be obtained for all trees in a stand when 60 years old.

The figures in Table 1 are an average of the growth under many difficult conditions of soil and moisture. On the less favorable sites, such as upper slopes and on wet bottoms, the rate of growth is slower than that of the average; on the more favorable sites, such as the better coves and limestone valleys, the rate of growth is more rapid. Individual trees in particular will be found, which depart widely from the average—especially larger trees among the dominant class in the even-aged stands, the growth of which is far more rapid, and the small trees in the suppressed class, the growth of which is much slower.

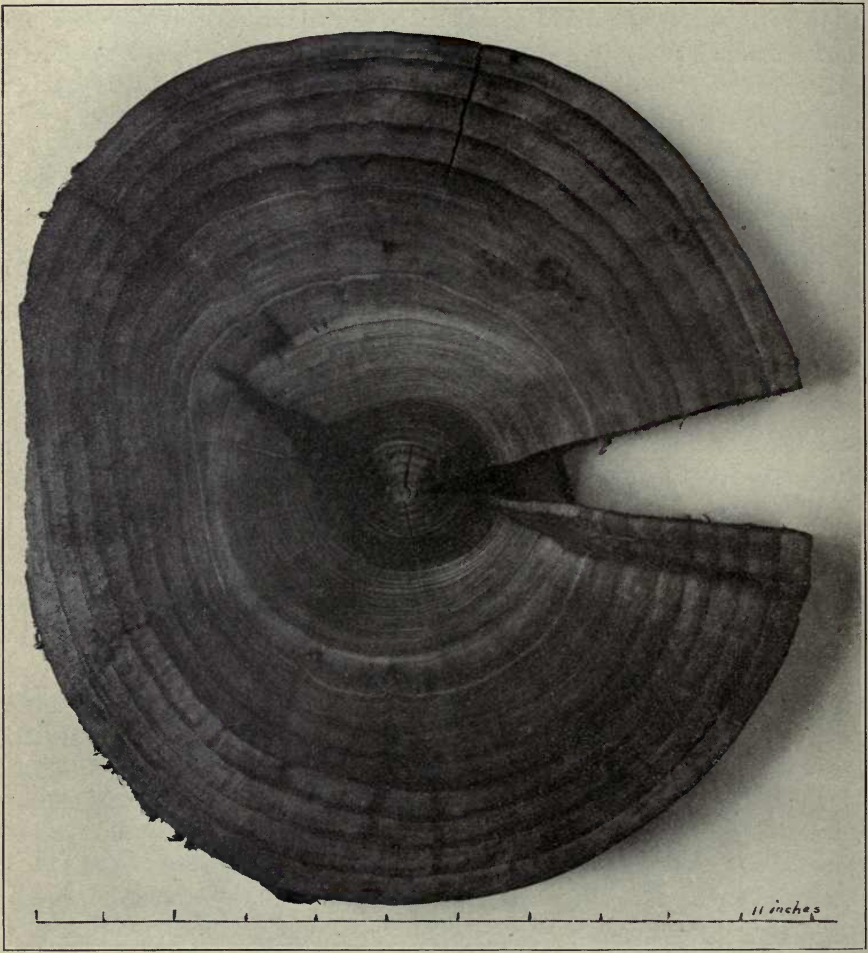


Fig. 3. Section of stem of yellow poplar 12 inches in diameter, illustrating accelerated growth following isolation. The growth in diameter during the last eight years amounted to 7 inches compared with the previous growth of 5 inches during 30 years while the stand was crowded.

Table 2 shows the volume in board feet ¼-inch saw kerf of trees of different heights and diameters.

TABLE 2.—*Volume in board feet of second growth trees of yellow poplar. Mill cut, ¼-inch saw kerf.*

Diameter breast-high Inches	Number of 16-foot logs per tree							Diameter inside bark of top Inches
	1	1½	2	2½	3	3½	4	
	Volume — Board feet							
7	19	38	54	..	..	..	..	6
8	20	41	59	78	..	..	..	6
9	23	44	64	85	..	..	..	6
10	25	48	70	90	120	..	..	6
11	27	52	77	99	130	150	..	7
12	29	57	83	110	140	170	210	7
13	32	61	90	120	150	190	230	7
14	33	68	99	140	170	210	250	7
15	35	72	110	140	180	230	270	7
16	37	78	120	150	200	240	290	7
17	39	85	130	170	220	260	320	7
18	41	90	140	180	230	290	340	8
19	..	110	150	200	250	310	360	8
20	..	..	170	220	270	320	390	8
21	..	..	..	230	290	350	410	8
22	..	..	..	250	320	380	440	8
23	..	..	..	..	330	410	470	8
24	..	..	..	..	350	420	500	8
25	..	..	..	..	..	440	520	8
26	..	..	..	..	..	470	550	8

TABLE 3.—*Volume of trees of yellow poplar of different diameters and heights as scaled by the Doyle-Scribner rule. Age class,* 50 *to* 100.

Diameter breast-high Inches	Height of tree — Feet							Diameter inside bark of top Inches
	70	80	90	100	110	120	130	
	Volume — Board feet in tens							
9	1	1	1	..	..	..	..	6
10	2	2	3	3	..	..	..	6
11	3	4	4	5	..	..	..	7
12	4	5	6	7	..	..	..	7
13	6	7	8	10	..	..	..	8
14	8	9	11	12	14	15	..	8
15	10	11	13	15	17	19	..	8
16	..	13	16	19	21	24	..	8
17	..	15	19	23	26	29	..	9
18	..	18	23	27	31	34	37	9
19	..	20	26	31	36	40	43	9
20	..	23	30	36	42	46	50	10
21	..	..	34	41	48	53	57	10
22	..	..	39	47	54	60	64	10
23	..	..	44	53	60	67	72	11
24	..	..	50	58	66	74	80	11
25	..	..	..	63	74	82	87	12
26	..	..	..	69	80	89	95	12
27	..	..	..	75	88	98	103	12
28	..	..	..	..	96	106	112	13
29	..	..	..	..	104	115	120	13
30	..	..	..	..	113	124	129	14

This table was made from taper curves by scaling the merchantable length in log lengths to the top diameters shown. Logs were 16.3 ft. long whenever possible, with some 14.3-ft., 12.3-ft., and 10.3-ft. logs to avoid waste. The assumed stump height was 2 feet.

TABLE 4 should read: *Volume in board feet of old trees of yellow poplar scaled by Scribner Rule; if the figures are rounded off to the nearest ten and read in tens, the reading is that of the Scribner Decimal C Rule.*

TABLE 3

heig

Diameter breast-high Inches	Height of tree — Feet							Diameter inside bark of top Inches.
	70	80	90	100	110	120	130	
	Volume — Board feet in tens							
9	1	1	1	..	..	..	..	6
10	2	2	3	3	..	..	..	6
11	3	4	4	5	..	..	..	7
12	4	5	6	7	..	..	..	7
13	6	7	8	10	..	..	..	8
14	8	9	11	12	14	15	..	8
15	10	11	13	15	17	19	..	8
16	..	13	16	19	21	24	..	8
17	..	15	19	23	26	29	..	9
18	..	18	23	27	31	34	37	9
19	..	20	26	31	36	40	43	9
20	..	23	30	36	42	46	50	10
21	..	..	34	41	48	53	57	10
22	..	..	39	47	54	60	64	10
23	..	..	44	53	60	67	72	11
24	..	..	50	58	66	74	80	11
25	..	..	..	63	74	82	87	12
26	..	..	..	69	80	89	95	12
27	..	..	..	75	88	98	103	12
28	..	..	..	..	96	106	112	13
29	..	..	..	..	104	115	120	13
30	..	..	..	..	113	124	129	14

This table was made from taper curves by scaling the merchantable length in log lengths to the top diameters shown. Logs were 16.3 ft. long whenever possible, with some 14.3-ft., 12.3-ft., and 10.3-ft. logs to avoid waste. The assumed stump height was 2 feet.

TABLE 4.—*Volume in board feet of old trees of yellow poplar scaled by Scribner Decimal C rule.*

Diameter breast-high Inches	Number of 16-foot logs											Diameter inside bark of top Inches
	1	1½	2	2½	3	3½	4	4½	5	5½	6	
	Volume — Board feet											
9	19	33	47	62	..	..	..	..	..	..	..	6
10	20	35	51	70	93	..	..	..	..	..	..	6
11	22	39	58	82	110	..	..	..	..	..	..	7
12	24	44	65	93	130	170	..	..	..	..	..	7
13	27	49	74	110	140	190	..	..	..	..	..	8
14	30	54	83	120	160	200	250	..	..	..	..	8
15	33	60	93	130	180	230	280	..	..	..	..	8
16	36	68	100	150	200	250	300	350	..	..	..	8
17	39	76	120	160	220	270	330	390	..	..	..	9
18	42	84	130	180	240	310	370	430	480	..	..	9
19	..	93	150	200	260	330	400	470	530	..	..	9
20	..	..	160	220	290	370	440	520	590	660	..	10
21	..	..	..	230	320	400	480	560	650	730	..	10
22	..	..	..	250	340	430	530	620	710	800	890	10
23	..	..	..	..	370	470	580	680	780	880	980	11
24	..	..	..	..	410	510	640	740	850	960	1,070	11
25	..	..	..	..	..	560	680	800	930	1,050	1,170	12
26	..	..	..	..	..	600	730	870	1,000	1,140	1,280	12
27	..	..	..	..	..	..	790	940	1,090	1,250	1,400	12
28	..	..	..	..	..	..	840	1,010	1,180	1,350	1,520	13
29	..	..	..	..	..	..	..	1,070	1,260	1,450	1,650	13
30	..	..	..	..	..	..	..	1,150	1,350	1,560	1,780	14

In the conversion of cubic feet into cords of pulp wood closely piled, peeled, dry and when the sticks are more than 12 inches in diameter, split, the number of cubic feet of solid wood required to make a cord, varies according to the diameter of the trees. Large wood piles more compactly than small, consequently a cord of such wood contains a larger number of cubic feet solid wood than a cord of wood from small trees. Table 5 shows the number of cubic feet of closely piled, peeled and split stem wood to three inches in diameter in the top, required to make a cord.

TABLE 5.—*Number of cubic feet of peeled stem wood in trees of different diameters to a cord of* 160 *cubic feet.*

Diameter of trees breast-high	Number of cubic feet of solid wood to a cord of 128 feet	Number of cubic feet of solid wood to a cord of 160 feet	Per cent of solid wood in a cubic foot
Below 7 inches.............	81.3	101.6	62.6
7 to 9 inches................	88.3	110.4	69.
10 inches and over.........	91.4	113.6	71.

Table 6 gives the volume in cords of 160 cubic feet of stem wood only, peeled, to three inches.

TABLE 6.—*Volume in cords of* 160 *cubic feet, of second growth trees of yellow poplar, stem wood, peeled, only to* 3 *inches in diameter.*

Diameter breast-high Inches	Height of trees — Feet 40	50	60	70	80	90	100	110
	Cords of 160 feet							
5	.018	.025	.032	.038	..	..	..	..
6	.027	.033	.042	.052	.060	..	..	..
7	.034	.043	.053	.064	.074	.083	..	..
8	.043	.055	.067	.080	.091	.103	.117	..
9	.053	.068	.084	.099	.113	.127	.140	..
10	.065	.085	.103	.121	.138	.153	.169	.187
11	.078	.103	.126	.147	.166	.185	.205	.226
12	.093	.125	.152	.176	.199	.222	.245	.269
13	.108	.150	.180	.208	.235	.263	.289	.316
14	..	.178	.212	.243	.274	.305	.336	.365
15	..	.210	.246	.280	.314	.349	.384	.418
16	..	..	.283	.319	.356	.393	.433	.470
17	..	..	.322	.361	.400	.440	.483	.523
18	..	..	..	.405	.446	.489	.532	.575
19	..	..	..	.450	.493	.538	.583	.628
20	..	..	..	..	.540	.587	.633	.682

Table 7 gives the number of mine props which can be cut from trees of different heights and diameters.

TABLE 7.—*Second-growth yellow poplar. Volume table for mine props from trees of different heights and diameters.*

Diameter breast-high	Height — Feet						
	40	50	60	70	80	90	100
Inches	Number of sections 5 ft. long and more than 5 in. inside bark at top						
5	..	..	2	..	..	..	..
6	2	3	4	..	..	..	..
7	2	4	5	5	7	..	..
8	3	5	6	7	8	..	..
9	4	5	6	8	9	..	..
10	4	6	7	8	10	..	..
11	4	6	7	9	10	10	..
	Number of sections 5 ft. long and more than 7 in. inside bark at top						
5	..	..	..	..	..	..	..
6	..	..	..	..	..	..	..
7	..	..	..	1	1	..	..
8	1	1	2	2	2	..	..
9	2	3	3	4	5	..	..
10	2	4	4	5	6	..	..
11	3	4	5	6	7	7	..
12	..	..	6	7	8	9	..
	Number of sections 7 ft. long and more than 5 in. inside bark at top						
5	..	..	1	..	..	..	..
6	1	2	3	..	..	..	..
7	2	3	3	4	5	..	..
8	2	3	4	5	5	..	..
9	2	4	4	5	6	..	..
10	3	4	5	6	7	..	..
11	3	4	5	6	7	8	..
	Number of sections 7 ft. long and more than 7 in. inside bark at top						
5	..	..	..	..	..	..	..
6	..	..	..	..	..	..	..
7	..	..	..	..	1	..	..
8	..	1	1	1	1	..	..
9	1	2	2	3	3	..	..
10	1	2	3	4	4	..	..
11	2	3	4	4	5	5	..
12	..	..	4	5	6	6	..

Yield.—Throughout Tennessee, in old pastures and in hollows on cut-over land, there are stands of second growth poplars. These are sometimes pure, consisting only of poplars, but as a rule contain varying proportions of other species, which are chiefly pine, oak, locust, and chestnut. Yield tables show the probable volume per acre of such stands at different ages, as well as the possibilities of plantations.

As in the case of individual trees, the growth of trees in such stands varies widely with the quality of the soil. Table 8 gives the yield per acre under different conditions of growth of pure unthinned stands of yellow poplar at different ages, in board feet from all trees 10 inches and over in diameter breast-high, outside of bark, and the cord wood suitable for pulp in small trees and tops. Stands which have been thinned and otherwise cared for should give larger yields than shown.

TABLE 8.—*Column "a" includes the saw timber from trees* 10 *inches and over; column "b", the cordwood in trees* 5 *to* 9 *inches which are too small to be cut into saw timber; column "c", the cordwood in the tops of trees in column "a"; column "d", the sum of columns "b" and "c"; column "e", the cordwood in column "a" converted into cordwood plus columns "b" and "c".*

Age of stand	Yield of saw timber from trees 10 in. and over in diameter outside bark breast-high	Yield of cordwood in connection with saw timber			Yield in cords of all the stem wood in all the trees 5 inches and over in stand
		From trees 5 to 9 in. in diameter outside bark breast-high	In tops of trees 10 inches and over in diameter breast-high	Total yield of cordwood in addition to saw timber	
	a	*b*	*c*	*d*	*e*
Years	Board feet	Long cords	Long cords	Long cords	Long cords
		Good condition of growth			
20	5,490	11.4	1.1	12.5	19
30	14,310	12.1	2.6	14.7	31
40	21,780	11.2	3.2	14.4	41
50	28,440	9.4	4.0	13.4	49
60	34,020	7.5	4.2	11.7	56
		Average conditions of growth			
20	540	9.5	0.3	9.8	13
30	7,020	12.0	1.8	13.8	23
40	13,950	12.2	2.7	14.9	31
50	20,160	11.4	3.4	14.8	37
60	25,830	10.0	3.7	13.7	43
		Poor condition of growth			
30	1,800	10.5	1.0	11.5	17
40	7,920	12.0	1.8	13.8	23
50	13,680	12.2	2.3	14.5	28
60	18,630	11.5	3.0	14.8	..

Graded volume tables.—With the increase in the diameter of the tree there is also an increase in the width of the boards which can be sawed from the logs; a decrease in the amount of sapwood on the boards, and in the proportion of knots to the total width of boards and even in the actual number of knots. Yellow poplar lumber increases in value as the boards become wider, as the proportion of heartwood increases and as the number and size of the knots decrease. Consequently, lumber sawed from large trees is worth more per thousand feet than that from small trees which are growing under the same conditions.

Table 9 gives the per cent of the different grades of lumber sawed from trees of yellow poplar of different diameters, using a circular saw which takes ¼-inch kerf and sawing the boards 1⅛ inches thick to allow for shrinkage. This table, above a diameter of 12 inches, is derived from one prepared by E. A. Braniff, showing the yield of trees of yellow poplar when sawed with a band saw taking seven cuts to the inch. Mr. Braniff's figures were obtained at a mill in eastern Tennessee. There is a constant increase in the proportion as well as in the amount of the higher grades with trees of a larger diameter and a corresponding decrease in the proportion of the less valuable grades.

TABLE 9.—*Percentage of different grades of lumber sawed out of yellow poplar trees of different diameters. Diameters* 13 *inches and over, by E. A. Braniff.*

Diameter breast high	Nos. 1 and 2	Saps and selects	Wide box	No. 1 common	No. 2 common	No. 3 common	Total yield per tree
Inches	Per cent						Bd. ft.
9	..	..	..	4	74	22	30
10	..	..	..	8	70	22	41
11	..	..	..	11	66	23	54
12	..	1	..	12	64	23	68
13	..	2	..	14	62	22	86
14	..	3	..	14	61	22	117
15	..	4	..	15	59	22	144
16	..	5	..	16	57	22	180
17	1	6	..	17	55	21	210
18	2	7	..	18	52	21	248
19	3	8	..	19	50	20	293
20	4	9	..	20	47	20	342
21	5	10	..	20	45	20	395
22	6	11	..	21	43	19	456
23	8	12	1	21	40	18	521
24	9	13	1	22	38	17	591
25	11	13	1	22	36	17	669
26	12	13	2	23	34	16	749
27	14	13	2	23	33	15	833
28	16	12	3	23	31	15	932
29	19	11	4	23	29	14	1,030
30	20	11	4	23	28	14	1,125
31	22	10	5	23	27	13	1,227
32	23	10	5	23	26	13	1,326
33	24	9	5	23	26	13	1,427
34	26	9	6	22	25	12	1,533
35	28	8	6	22	24	12	1,649
36	29	8	6	22	23	12	1,742

The percentage of grades given in trees of diameter above 14 inches applies only to old growth trees. As a rule, small trees in second growth stands, 14 inches or less in diameter breast-high, saw out largely lumber of the grades No. 2 common and cull, together with smaller amounts of No. 1 common and sap grades than are given in the table. Clean stemmed second growth trees which are from 14 to 20 inches in diameter saw out a far larger, but somewhat variable, proportion of clear saps and a much smaller proportion of No. 1 and 2 grade than old forest trees of the same diameter.

Table 10 shows the amounts of the different grades of lumber sawed from trees of yellow poplar of different diameters and their values at Chattanooga, Knoxville, Nashville, Bristol, and other large shipping points in Middle and East Tennessee. Prices at points in West Tennessee are usually about 25 cents per 1,000 board feet lower.

The following prices of the different grades are used in determining the values of the lumber in totals:

Nos. 1 and 2	$53.50 per 1,000 board feet
Saps and selects	38.50 per 1,000 board feet
Wide box	40.00 per 1,000 board feet
No. 1 common	29.00 per 1,000 board feet
No. 2 common	18.00 per 1,000 board feet
No. 3 common	13.25 per 1,000 board feet

These were the prices in carload lots for July, 1913, at the important lumber centers of Tennessee.

TABLE 10.—*Amounts and values of the different grades of lumber sawed out of yellow poplar trees of different diameters, ¼-inch saw kerf. Values f. o. b. Nashville and other important points.*

Diameter breast-high	No. 1 and 2		Saps and selects		Wide box		No. 1 common		No. 2 common		No. 3 common		Total volume per tree	Total value per tree
Inches	Bd. ft.	Value	Bd. ft.	Value	Bd. ft.	Value	Bd. ft.	Value	Bd. ft.	Value	Bd. ft.	Value	Bd. ft.	Value
9	..	..	..	..	..	..	1	$ 0.03	22	$0.40	7	$0.09	30	$ 0.52
10	..	..	..	..	..	..	3	.09	29	.52	9	.12	41	.73
11	..	..	..	..	..	..	6	.17	36	.65	12	.16	54	.98
12	..	..	1	$0.04	..	..	8	.23	44	.79	16	.21	68	1.27
13	..	..	2	.08	..	..	12	.35	53	.95	19	.25	86	1.63
14	..	..	4	.15	..	..	16	.46	71	1.28	26	.34	117	2.23
15	..	..	6	.23	..	..	22	.64	85	1.53	32	.42	144	2.82
16	..	..	9	.35	..	..	29	.84	103	1.85	40	.53	180	3.57
17	2	$ 0.11	13	.50	..	..	36	1.04	116	2.09	44	.58	210	4.32
18	5	.27	17	.65	..	..	45	1.31	129	2.32	52	.69	248	5.24
19	9	.48	23	.89	..	..	56	1.62	147	2.65	59	.78	293	6.42
20	14	.75	31	1.19	..	..	68	1.97	161	2.90	68	.90	342	7.71
21	20	1.07	40	1.54	..	..	79	2.29	178	3.20	79	1.05	395	9.15
22	27	1.44	50	1.93	..	..	96	2.78	196	3.53	87	1.15	456	10.83
23	42	2.25	63	2.43	5	$0.25	109	3.16	208	3.74	94	1.25	521	13.08
24	53	2.84	77	2.96	6	.30	130	3.77	225	4.05	100	1.33	591	15.25
25	74	3.96	87	3.35	7	.35	147	4.26	241	4.34	114	1.51	669	17.77
26	90	4.82	97	3.73	15	.75	172	4.99	255	4.59	120	1.59	749	20.47
27	117	6.26	108	4.16	17	.85	192	5.57	275	4.95	125	1.66	833	23.45
28	149	7.97	112	4.31	28	1.40	214	6.21	289	5.20	140	1.86	932	26.95
29	196	10.49	113	4.35	41	2.05	237	6.87	299	5.38	144	1.91	1030	31.05
30	225	12.04	124	4.77	45	2.25	259	7.51	315	5.67	158	2.09	1125	34.33
31	270	14.45	123	4.74	61	3.05	282	8.18	331	5.96	160	2.12	1227	38.50
32	305	16.32	133	5.12	66	3.30	305	8.85	345	6.21	172	2.28	1326	42.08
33	342	18.30	128	4.93	71	3.55	328	9.51	371	6.68	186	2.46	1427	45.43
34	399	21.35	138	5.31	92	4.60	337	9.77	383	6.89	184	2.44	1533	50.36
35	462	24.72	132	5.08	99	4.95	363	10.53	396	7.13	198	2.62	1649	55.03
36	505	27.02	139	5.38	105	5.25	283	11.11	401	7.22	209	2.77	1742	58.72

Increase in value with size.—Table 11 shows the value per 1,000 board feet of lumber sawed from trees of different diameters and the value of lumber sawed from each tree f. o. b. Knoxville, Tennessee, and the stumpage value per tree under operating expenses of $10, $12, $14, and $16 per 1,000 board feet.

TABLE 11.—*Stumpage values of trees of different sizes under different costs of operation and the stumpage value per* 1,000 *feet of the lumber from such trees.*

Diameter breast-high Inches	Value of lumber per 1,000 ft. f. o. b. Nashville	Value of stumpage per 1,000 Bd. ft. costs per 1,000 Bd. ft.				Value of stumpage per tree operating costs per 1,000 Bd. ft.			
		$10	$12	$14	$16	$10	$12	$14	$16
9	$17.33	$ 7.33	$ 5.33	$ 3.33	$ 1.33	$ 0.22	$ 0.16	$ 0.10	$ 0.04
10	17.80	7.80	5.80	3.80	1.80	.32	.24	.16	.08
11	18.15	8.15	6.15	4.15	2.15	.44	.33	.22	.11
12	18.68	8.68	6.68	4.68	2.68	.59	.45	.32	.19
13	18.95	8.95	6.95	4.95	2.98	.77	.60	.43	.26
14	19.06	9.06	7.06	5.06	3.06	1.06	.83	.59	.35
15	19.58	9.58	7.56	5.56	3.56	1.38	1.09	.80	.51
16	19.83	9.83	7.83	5.83	3.83	1.77	1.41	1.05	.69
17	20.57	10.57	8.57	6.57	4.57	2.22	1.80	1.30	.96
18	21.13	11.13	9.13	7.13	5.13	2.76	2.26	1.77	1.28
19	21.91	11.91	9.91	7.91	5.91	3.49	2.90	2.32	1.74
20	22.64	12.64	10.64	8.64	6.64	4.29	3.61	2.92	2.23
21	23.16	13.16	11.16	9.16	7.16	5.20	4.41	3.62	2.83
22	23.75	13.75	11.75	9.75	7.75	6.27	5.36	4.45	3.54
23	25.11	15.11	13.11	11.11	9.11	7.87	6.83	5.79	4.75
24	25.80	15.80	13.80	11.80	9.80	9.34	8.16	6.98	5.80
25	26.56	16.56	14.56	12.56	10.56	11.08	9.74	8.40	6.06
26	27.33	17.33	15.33	13.33	11.33	12.98	11.48	9.98	8.48
27	28.15	18.15	16.15	14.15	12.15	15.12	13.45	11.79	10.13
28	28.92	18.92	16.92	14.92	12.92	17.63	15.77	13.90	11.03
29	30.15	20.15	18.15	16.15	14.15	20.75	18.69	16.63	14.57
30	30.52	20.52	18.52	16.52	14.52	23.08	20.83	18.58	16.33
31	31.38	21.38	19.38	17.38	15.38	26.23	23.78	21.32	18.86
32	31.73	21.73	19.73	17.73	15.73	28.82	26.17	23.52	20.87
33	31.84	21.84	19.84	17.84	15.84	31.16	28.31	25.45	22.59
34	32.85	22.85	20.85	18.85	16.85	35.03	31.96	28.90	25.84
35	33.37	23.37	21.37	19.37	17.37	38.54	35.24	31.94	28.64
36	33.71	23.71	21.71	19.71	17.71	41.30	37.82	34.33	30.84

Operating expenses embrace the costs of logging, sawing, selling, grading, insurance, carrying stock, carrying timber, salaries and all overhead charges; cost of hauling or transporting from mill to railroad; an allowance for difference in freight to compensate for the difference in the price of lumber at points which have a higher freight rate than the lumber centers, and includes all profits in operating and selling. Operating expenses vary with the accessibility of timber, class of operation, and the ability of the operators. The average expense at present in producing yellow poplar in Tennessee is above $14 per 1,000 board feet. The allowance for difference in freight rates amounts to 30 cents per 1,000 board feet for each difference of 1 per cent per 100 pounds in the freight rate. This difference should be deducted from the value shown in Table 11 when the freight rate is less than the rate from the lumber centers, and added when the freight rate is higher. The prices given for lumber are based on well graded and well sawed stock in car lots. When lumber is sold through brokers and commission men the prices are from 5 to 8 per cent. less.

The value of the yellow poplar trees in a stand are determined by ascertaining by measuring and tallying the number of trees of each diameter, and multiplying these numbers by the value of trees of the respective diameters under the appropriate cost of operating.

Increase in price.—In addition to the increase in volume and increase in quality, which accompanies growth, due to increase in the proportion of higher grades, there is a third but irregular increase in value due to increase in price. Since this increase varies with the proportion of the different grades of lumber which can be sawed from the tree, it can be calculated only by considering the increase in the price of these component grades. During the past 20 years there has been a greater per cent. of increase in the prices of lower grades than in those of the higher grades. The higher grades, consisting of Nos. 1 and 2, and saps, have increased in price at Knoxville about 3.7 per cent, compounded per year; lower grades No. 2 common and No. 3 common at a rate of about 4.9 per cent. a year. This increase in the price of the lower grades should be considered as one of the elements of increased value in plantations and in young stands which contain a large proportion of poplar trees and which are being managed as investments. Second growth trees of small saw log size yield largely No. 2 common grade of lumber. The rate per cent. of increase in the price of this grade during the past 10 years indicates the probable rate of increase in the price of small sap trees during the next 10 or 20 years. In 1903 this grade sold for $13 per 1,000 board feet at Tennessee points. Under an operating cost of $12 per 1,000 board feet this grade at that time had a stumpage value of $3 per 1,000 feet; its stumpage value in 1913 under an operating cost of $12 per 1,000 board feet is $5. The rate of increase in value during the decade was 5.2 per cent a year. If this rate of increase in price continues for the next two or three decades, and is considered in connection with the increase in the value of stands and individual trees by growth and quality, there is an assurance of an excellent rate of profit from the management of pure stands of young trees and from plantations.

Table 12 shows the rate per cent. of increase in the price of the most important grades of lumber at the chief Tennessee shipping points:

TABLE 12.—*Rate per cent., compound, increase in the price of the important grades of yellow poplar lumber at Tennessee points during the 20-year period* 1893-1913.

Grades	Price in 1893	Price in 1913	Rate per cent. of increase in price compound
No. 1 and 2	$25.00	$53.00	3.9
Saps and selects	19.00	38.50	3.6
No. 1 common	16.00	29.00	3.
No. 2 common	7.00*	18.00	4.8
No. 3 common	5.00*	13.25	5.

Estimated stumpage has increased at a higher rate than lumber. A 28-inch tree may be regarded as of average size in operation during the past 20 years. In 1893 lumber from trees of this diameter had an f. o. b. value of $11.86 per 1,000 board feet. No logs which would cut largely No. 2 and No. 3 common would be taken to the mill. The average cost of operation at that time may be placed at $10.70 per 1,000. In 1913, on account of the increase in wages and supplies, the cost of operation under the same conditions is $16 per 1,000 board feet. In 1913 the f. o. b. value of lumber from an average tree 28 inches in diameter breast-high is $28.92 per 1,000 feet, at important shipping points in Tennessee. These figures give stumpage values of $1.16 per 1,000 board feet in 1893; and $12.92 per 1,000 board feet in 1913. The increase in value of the stumpage of a tree of this diameter has been at a rate of 13 per cent., compounded, a year. Such a rate will scarcely continue for the next decade, since the tendency of the rate of increase is to decline as the base on which it is calculated becomes larger, although the actual amount of increase may be the same.

INCREASING THE YIELD FROM TIMBER LAND.

The rate of growth of trees and the yield of timberland are as a rule greatly overestimated by owners. Their opinions have been formed as a result of the method of cutting which has been used on many tracts of timber. While it is true that many tracts have been cut over several times, only a small portion of the merchantable timber was cut in the earlier operations. In the first cutting, as a rule, the larger and more valuable trees were taken to 24 or 30 inches in diameter. A subsequent cutting removed some of the inferior large trees, and cut the more valuaable trees to 20 inches; and a third one, made probably 20 years after the first, removing a lower grade, cut to 16 inches. No cutting has thus far removed all of the stand. So long as there remains a large number of trees 14 to 20 inches in diameter, the annual growth in board feet per acre is large, and if cutting is not below a diameter of 18 or 20 inches, comparatively heavy yields can be obtained every 15 or 20 years from the same tract. As soon, however, as cutting is to a diameter below 10 inches, not only must a very much longer time elapse before another profitable cutting of large timber can be obtained, but there is a loss in converting into lumber, since, while the waste of kerf and slabs in the case of larger timber is only 50 per cent., it is 75 per cent. in the case of small timber. While cutting to too small a diameter over an entire tract is to be avoided, other requirements must be considered.

There is no single operation or process the use of which will develop the maximum earnings of a forest which contains yellow poplar. The following are the most important points to consider in seeking to develop and maintain on a tract a high yield of yellow poplar, and to secure a product of high value.

Management.
(1) Developing a form of stand which permits intensive operations.
(2) Cutting trees only at or above a size which indicates maturity.
(3) Obtaining full-stocked stands by preventing fires and by regulating grazing.
(4) Eliminating species of low value from stands.
(5) Thinning young stands in order to accelerate growth.

Better Utilization.
(6) Reduction of waste and closer utilization of timber.
(7) Selling timber in its most profitable form.

MANAGEMENT.

Developing a desirable form of stand.—By procuring a suitable form of stand, the conditions are obtained which are best suited for the replacement and most rapid growth of the valuable species in the stand, since yellow poplar requires a large amount of light for its establishment and growth, and its most rapid development takes place in even-aged stands and groups.

Sprout forms.—While young trees sprout sufficiently to be managed as sprout stands, this form of stand can be used only for the production of small timber, such as pulp wood, and is advisable only on good sites where pure stands of yellow poplar can be grown, or mixtures of yellow poplar with chestnut, red oak, locust, and other species which sprout. The rotation or period required for the maturity of a coppice stand is from 20 to 35 years. Sprout trees which are much older than 35 years, frequently become so defective at the butt that they break off. Sprout stands should be even-aged or in even-aged groups.

High forest forms.—For the production of saw timber, yellow poplar can be managed only with seedling trees in high forest. Of the different high-forest forms, yellow poplar is well suited only to even-aged stands, in which all the trees in one cutting unit or block are of the same age or approximately so; or to a group or strip form in which the trees occur in even-aged strips or groups. The groups or strips can be made so small as to develop a group or strip selection form. Such stands can be either pure or mixed. The single tree selection form of forest (which consists of trees of all ages mixed in the stand) with its more restricted light conditions is not so well adapted to securing the replacement of yellow poplar. The group and strip forms seem to particularly meet the requirements of yellow poplar in mountain forests.

(1) The advantage of the group or strip forms are that profitable cuttings of large timber can be made in the same cove or valley at short intervals. When the growth is rapid, the intervals between cuttings might not exceed 15 years.

(2) Since the mature groups are cut clean, there is no breakage of small timber in felling as is the case when culling and simple selection is practiced.

(3) Large timber can be logged to loaders by cable with less serious breakage of small trees.

(4) Restocking with yellow poplar and white pine is more easily obtained in the center of openings, while nearby oaks seed up the edges.

(5) The soil is better protected from erosion than it is in the case of clean cutting, and there is less danger of destruction by fire on the cut-over areas. The intermixture of species with heavy crowns, likewise assures protection of the soil from drying winds.

(6) With groups of young timber adjacent to groups which are mature, more intensive management can be practiced than is possible in the case of selection stands. It is possible to make thinnings in groups of immature trees, thus freeing the larger trees in these groups, and accelerating their growth. At the same time, the small timber which is removed in thinnings, and which otherwise would be lost, can be utilized.

Applying this method of cutting to a farm forest of 100 acres in which an ideal form of stand has already been developed, there would be one group of trees which would be mature and which would be cut that year or during the cutting period, which might be as long as 10 years. If 50 years were required for the trees to fully mature, one-fifth of the forest, or 20 acres, would be mature and ready to be cut during this period of 10 years. One-fifth, or 20 acres, would have been cut over during the preceding 10 years, and would have restocked in small seedlings; 20 acres would bear a stand with an average age of 15 years. The stand on 20 acres would have an average age of 25 years; while that on 20 acres would have an average age of 35 years. At the same time that saw timber was being cut in the mature stand, large poles would be removed in thinning the 35-year-old tract; small poles would be removed in thinning the 25-year-old stand, and small saplings in thinning the 15-year-old stand. This would insure a continuous supply of large timber as the areas of the different age-classes matured. At the same time there is always an area in process of restocking equal to that which is being cut over. In a large tract, each cove might take the place of the 100-acre tract, and a suitable grouping of age classed be obtained in it.

In developing groups, they may vary in size from 100 feet square to two or three acres in extent. Strips, which in a mountainous region might be located up and down the slope, may be from three to five chains wide, or as might often be advisable in the mountains, they might coincide with the limits of narrow coves or hollows. On small tracts, such as farm forests, blocks or cutting units which are designated with the object of facilitating management, might be so small as to form in reality a group selection form.

Natural forests seldom occur in the forms which have been recommended, but the tendency is for even-aged stands to result from clean cutting. There is also a tendency in the mountainous portions of Tennessee for the formation of even-aged second growth stands in the coves and hollows, where these are cut clean and for the formation on the slopes of even-aged groups or strips of young timber alternating with groups or strips of old timber which were not felled, either because they were less accessible or because they were largely composed of inferior species or low-grade trees. In extensive operations, this last condition forms a basis for ultimate conversion into a form of groups or strips which is adapted to logging at frequent intervals. It is impossible to convert from the present irregular form of stand without some slight cost; and in the case of large and inaccessible tracts on which operating charges are high, conversion must be affected gradually in order to reduce the cost. A compromise, consequently, is necessary. The owner foregoes a part of his present profit with the expectation of greatly increasing the earning power of his land at the date when future cuttings are made. A tree is left in one place which could be removed at a slight present profit, but which is increasing in value at a high rate. Another tree is taken which offers less profit, because it is declining in value and interfering with the growth of valuable young timber. The action in both cases looks toward the resultant form of forest and the profit accrues to the date of future cuttings. It is as desirable that a definite form of forest be developed in the management of small tracts of from 50 to 100 acres as in the case of large tracts of 10,000 or more acres. While it is often impossible on a large tract, on account of increasing logging costs, to cut for the best future interests of the forest, there are no such restrictions in the case of small tracts on farms. The farmer can generally use his own teams and can log carefully, cutting a portion of this tract each year. In this way, he is in a position in a few decades to obtain a form of forest which will produce more profitably a much higher yield than is possible in the case of large and inaccessible tracts. The tendency of yellow poplar to occur in groups in second growth stands is shown.

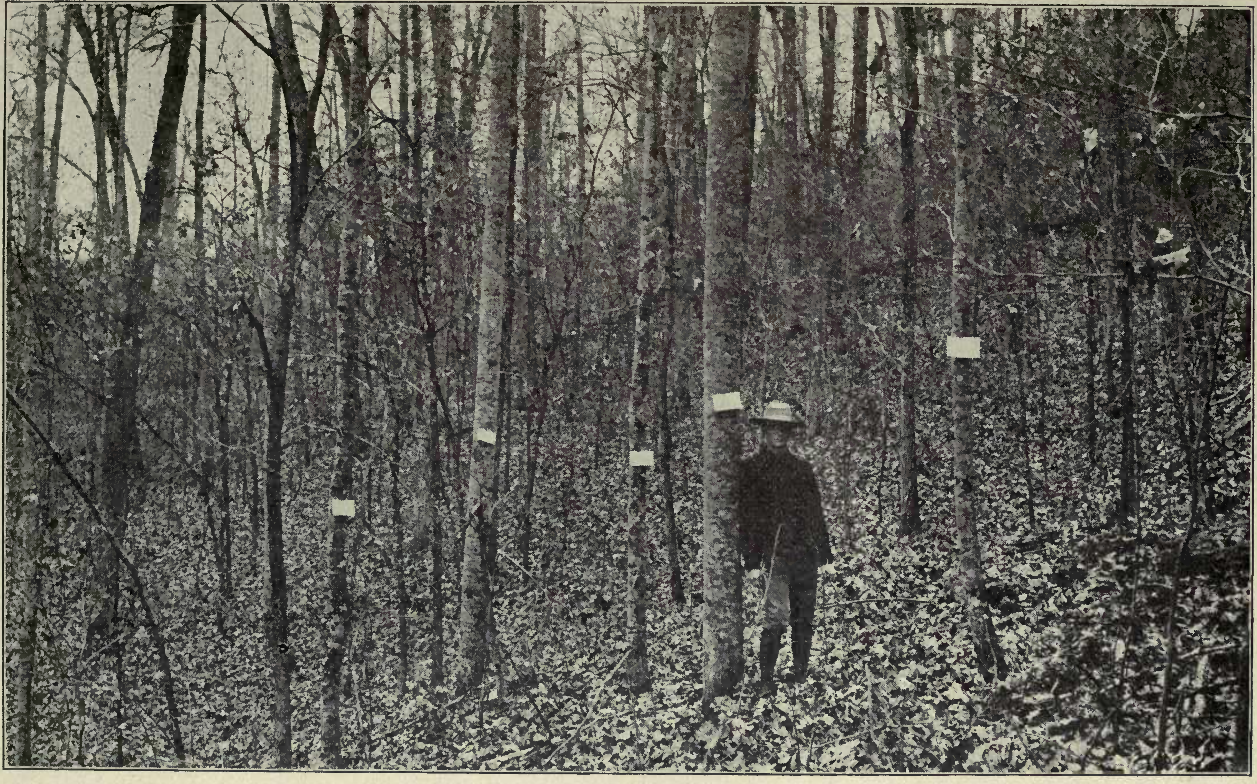


FIG. 4. Group of yellow poplar poles in a crowded stand of mixed species 20 to 30 years old. The crowding should be relieved by cutting some of the middle size (intermediate) trees and the defective dominant (large) trees. The well shaped dominant trees should not be cut at the present time, neither should the suppressed trees which, while they can not be expected to make sawlogs, still serve a useful purpose in shading the soil and maintaining its moisture supply. This illustrates the tendency of yellow poplar to form groups. (Photo Forest Service.)

MATURITY OF TIMBER.

Single trees in mixed stands.—Single trees of yellow poplar can be considered mature financially when their annual rate of increase in value becomes equal to the current rate of interest on money. If timber is held after the rate of increase in value falls below the interest rate, there is a loss, since if the timber had been sold, the proceeds could have been invested as loans at the current interest rate on money. Table 13 shows the rate of increase in value by growth of trees of yellow poplar under different costs of logging while increasing one inch in diameter. This does not include the increase in price, and the current increase in price should always be considered in connection with this table. While price increase of large poplar has been very high in the past, the rate will probably decline in the future.

The rate of increase in the price of second growth for the past decade has been only about 5 per cent. Although yielding well above the current rate of interest, if the present rate of increase in price is also considered, 16 inches might be considered a diameter for cutting when the cost of operating is low; 18 inches when the cost is about $13 per 1,000 board feet; and 20 inches when the cost of operating is more than $15 per 1,000 board feet. The rate of growth of the timber also affects its increase in value. On the best sites, such as very fertile coves where poplar will produce four and five logs 16 feet long, including the cull top log, these diameters might be two inches larger respectively. On very poor sites where only two and three logs can be cut from the trees, and those are sappy, knotty, or otherwise low grade, the diameter for cutting can be 15 inches breast-high, under a low cost of operation, 17 inches under an average cost, and 19 inches under a high cost of operation.

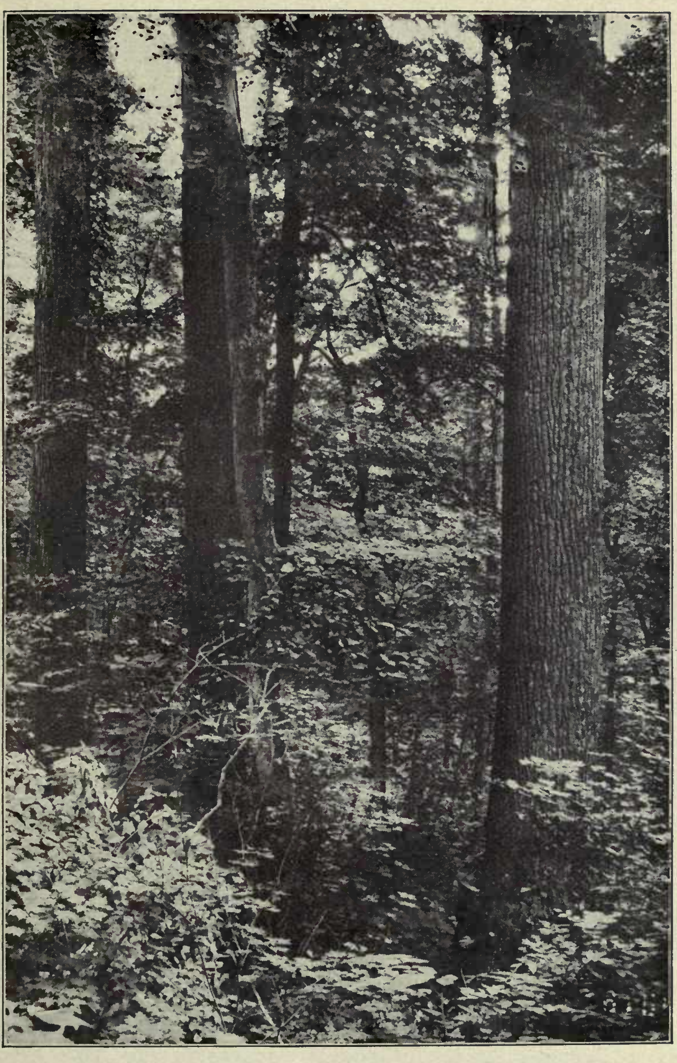


FIG. 5. A virgin stand of mixed hardwoods which contains a large proportion of yellow poplar. The merchantable trees in this stand of other species, as well as yellow poplar, are mostly of very large size. The small trees in the stand are suppressed or specimens of small tolerant species. This stand requires cutting clean except for seed trees. It will be necessary to destroy the heavy undergrowth of trees and shrubs which are tolerant of shade in order to be assured of a large proportion of yellow poplar in the restocking. (Photo Forest Service.)

TABLE 13.—*Time required for trees of yellow poplar to grow one inch in diameter, under average conditions, and annual rate per cent. of increase in value by growth.*

		Operating costs $12 a 1,000 board feet		Operating costs $16 a 1,000 board feet	
Diameter of tree breast-high	Time required to grow 1 inch in diameter	Stumpage value per tree	Rate of increase in value a year	Stumpage value per tree	Rate of increase in value a year
Inches	Years	Value	Per cent.	Value	Per cent.
9	..	.16	..	.04	..
10	3.5	.24	12.3	.08	21.9
11	4.0	.33	8.3	.12	13.3
12	4.0	.45	8.1	.19	10.6
13	4.0	.60	7.5	.26	8.1
14	4.0	.83	8.4	.35	7.7
15	4.5	1.09	6.2	.51	8.7
16	5.0	1.41	5.3	.69	6.2
17	5.5	1.80	4.5	.96	6.2
18	5.5	2.26	4.2	1.28	5.4
19	5.5	2.90	4.6	1.74	5.7
20	6.0	3.61	3.7	2.23	4.2
21	7.0	4.41	2.9	2.83	3.5
22	7.0	5.36	2.8	3.54	3.3
23	8.0	6.83	3.1	4.75	3.7
24	9.0	8.16	2.0	5.80	2.2
25	9.0	9.74	2.0	7.06	2.2
26	9.0	11.48	1.8	8.48	2.0
27	10.0	13.45	1.6	10.13	1.8
28	10.0	15.77	1.6	11.03	0.9

Determination of the future yield in mixed selection stands.—In connection with the management of selection stands of mixed forest, it is frequently desirable to know what yield of yellow poplar can be expected from a tract at different future periods, or what number of poplar trees of different diameter classes it would be necessary to have growing, to provide for a sustained yield (normal distribution of age classes). The following table enables this to be determined, if the poplar in the stand is in unthinned groups. It shows for average conditions of soil what should be the relative number of trees of different diameter classes to an acre, to provide for a sustained annual yield of 430 board feet on average quality sites, which would be the yield from fully stocked acres of pure stands if each diameter class occupies the same proportional crown area.

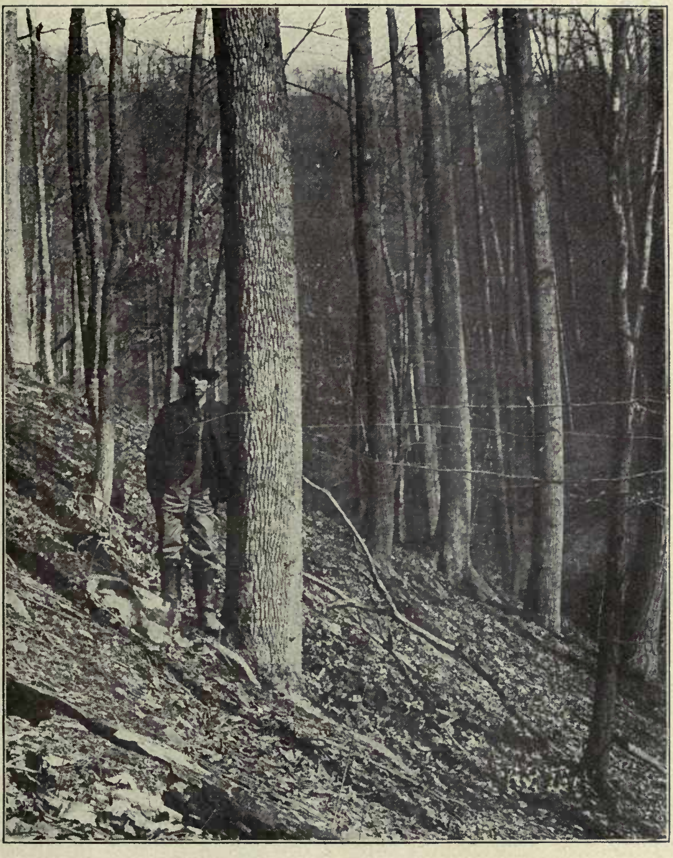


FIG. 6. A second-growth stand of mixed hardwoods which contains a large number of medium sized yellow poplars. A diameter limit (selection system) for cutting could advantageously be applied to this stand since it contains many small and medium sized trees. Openings should be made sufficiently large, however, by group cutting to ensure the replacement of poplar on them, since the site is evidently well suited to the growth of this species. The absence of young growth indicates that the present forest cover is dense. (Photo Forest Service.)

Number of trees in different diameter classes per acre, required to obtain a continuous yield from a fully stocked group selection stand of pure poplar.

Diameter classes breast-high Inches	Number of trees per acre on average quality sites	Approximate per cent of each diameter class which should exist in a normal stand
2- 4	280	54.00
5- 8	151	30.00
9-12	57	11.00
13-16	19	4.00
17-20	5	1.00
above 20	1	.30
Total per acre	513	

Since this table is based on fully stocked pure stands, it is necessary in the consideration of a mixed stand to ascertain the average number of trees of the different diameter classes per acre. The relation of this number in each diameter class to the corresponding table number gives the proportional annual yield which is to be expected from this diameter class when mature, that is, when larger than 20 inches in diameter.

If in place of 19 trees to the acre, in the 13 to 16 inch diameter class there were 6 trees, the proportion of stocking would be 6-19, so far as this diameter class were concerned. The annual yield per acre from a fully stocked stand is 430 board feet, consequently the annual yield with the proportion of stocking given would be 6-19×430=135 board feet. If the average diameter of the 6 trees per acre in this diameter class were 15 inches, it would be (see table 13) 22 years before they were 20 inches and ready to cut. If the interval between cuttings was 10 years the yield would be 10×135=1,350 board feet per acre at that time. This is based on the assumption that poplar trees growing in groups in mixed stands have approximately the rate of growth that they have in pure stands. In strict selection or natural irregular stands in which single trees of yellow poplar compete with slower growing species, the young poplars are more persistent than when they occur in pure groups, and a smaller proportion of them die during the life of the stand.

If such mixed selection stands where the yellow poplar trees occur as single trees, the crown spread of the dominant trees is the most reliable basis to use in determining the proportion which yellow poplar contributes to the stocking of the stand. There is given below the average diameter of the crown spread in feet of dominant and intermediate trees of yellow poplar from 7 to 22 inches in diameter breast-high. Dominant trees, particularly such trees in thinned stands, have a wider crown spread than is given. The maximum crown spread which can be obtained without unduly developing the crown at the expense of the clear length of stem would be one-half more than is given.

Breast-high diameter of tree, inches	Spread of crown feet	Breast-high diameter of tree, inches	Spread of crown feet
7	11	15	16.5
8	11.6	16	17.2
9	12.4	17	17.9
10	13.3	18	18.6
11	13.7	19	19.4
12	14.4	20	20
13	15.1	21	27.7
14	15.8	22	21.3

Pure stands.—The maturity of pure, even-aged stands is determined by the date at which the largest profit or per cent. is earned on the investment. The investment embraces—

(1) The value of the soil;

(2) The cost of establishing the stand, which might consist either in leaving seed trees, or increased cost of logging the old stand, or the cost of seeding or planting;

(3) The cost of protection, which may be a yearly cost or might be required only while the stand was young, and the interest on such costs;

(4) Taxes on soil and timber, and the interest on taxes;

(5) The cost of thinning and cleanings and the interest on such expenses.

The volume of a pure, even-aged stand increases rapidly at first, then more slowly and finally becomes stationary. The value of the timber based on the quality or proportion of grades increases in the same manner. Value increment continues long after the volume of the stand has become stationary.

There is also, as has been explained, a fluctuating increase in price of grades of lumber, which affects the value of stumpage. This is neglected in all calculations, but it should be given careful consideration by owners of stands in fixing the period of cutting. Table 14 shows the cost per 1,000 board feet of growing yellow poplar in pure stands, and the most profitable age at which to cut, when the cost of stocking is $3 an acre and when the detailed items of expense are as shown. The greatest profit per 1,000 board feet, 49 cents, in excess of all costs and interest, is made by cutting at 35 years of age. At 30 years the profit is 42 cents per 1,000 feet; at 40 years it is 36 cents a 1,000 feet. Price increase is neglected.

TABLE 14.—*Second-growth yellow poplar. Most profitable age for cutting unthinned stands for lumber, and the cost per 1,000 board feet of growing timber with natural reproduction. Average sites. Interest rate, 5 per cent; value of soil, $5 per acre; cost of stocking, $3 per acre.*

	EXPENSES IN GROWING TIMBER											
	Cost of land, stocking and protection				Taxes							
					on timber		on land					
Age of stand	Value of stumpage per acre at end of each 5-year period at present prices	Accrued interest on value of land to end of each 5-year period	Cost of stocking and interest on it to end of each 5-year period	Cost of protection 5 cents per acre per year, and accrued interest to end of each 5 year period.	Annual for each 5-year period at 1 per cent. on a two-thirds valuation of stand.	Taxes and accrued interest at 5 per cent. to end of each 5-year period.	Taxes at 1 per cent. on land at uniform value and accrued interest to end of each 5-year period.	Total cost of growing timber to the end of each 5-year period.	Profit or loss in excess of 5 per cent. on the basis of present stumpage values.	Cost of 1,000 Bd. ft. of growing stand.	Value per 1,000 Bd. ft. of stand on basis of present prices of lumber.	Per cent. of increase in stumpage values necessary to yield 5 per cent. net.
Years	Per acre	Per acre	Per acre	Per acre	Per acre	Per acre	Per acre	Per acre	Per acre	Per 1,000 feet	Per 1,000 feet	Per cent
20	$ 17	$ 8.27	$ 7.96	$ 1.65	$0.12	$....	$ 1.65	$ 19.53	$*2.53	$3.83	3.33	..
25	29	11.93	10.16	2.39	.18	0.66	2.39	27.53	1.47	3.03	3.19	..
30	43	16.61	12.96	3.32	.28	1.84	3.32	38.05	4.95	2.95	3.33	..
35	60	22.58	16.55	4.52	.40	3.90	4.52	52.07	7.93	3.19	3.68	..
40	78	30.20	21.12	6.04	.52	7.20	6.04	70.60	7.40	3.64	4.02	..
45	97	39.93	26.95	7.99	.64	12.09	7.99	94.95	2.05	4.24	4.33	..
50	114	52.34	34.40	10.47	.76	19.01	10.47	126.69	*12.69	5.03	4.52	0.2
55	130	68.18	43.91	13.64	.87	28.53	13.64	167.90	*37.90	6.04	4.68	.5
60	143	88.40	56.04	17.68	.95	41.33	17.68	221.13	*78.13	7.30	4.72	.7

---

*Loss.

Table 15 shows the most profitable diameters and ages at which to cut stands of second growth yellow poplar which have been established without cost and which are unthinned, cutting to different diameters. When the current rate per cent. of increase in value falls below 6 per cent. the stand can be considered as mature. It should be noted that price increment is neglected.

TABLE 15.—*Yellow Poplar. Period of maturity of natural unthinned second-growth stands for saw-timber. Average conditions of growth. Price increment neglected.*

	Cutting to 7 inches breast-high				Cutting to 10 inches breast-high		
Age of stand	Average diameter breast-high of trees in stand	Value of stand per acre saw-timber only	Average annual increase in value	Current rate of increase in value	Average diameter breast-high of trees over 10 inches in diameter	Value of stand per acre saw-timber only	Average annual increase in value
Years	Inches			Per cent.	Inches		
20	4.9	$ 17	$0.85	23.0	10.5	$ 6	$0.30
25	5.9	29	1.16	11.0	11.2	22	.88
30	6.8	43	1.43	8.0	11.7	39	1.30
35	7.6	60	1.71	7.0	12.1	55	1.60
40	8.3	78	1.95	5.0	12.3	73	1.82
45	9.0	97	2.16	4.5	12.6	92	2.04
50	9.5	114	2.28	3.3	12.8	110	2.20
55	10.0	130	2.36	2.7	13.0	126	2.30
60	10.4	143	2.38	2.0	13.1	139	2.33
65	10.8	154	2.37	1.5	....	....	....

Table 16 shows the cost of growing cordwood and the most profitable age at which to cut cordwood in natural stands. The greatest profit per acre, in addition to interest, is at 25 years, and amounts to $10.47 an acre. The cost of growing timber at this age is only $1.45 a cord; much lower than when the stand is either younger or older.

TABLE 16.—*Second-growth yellow poplar. Most profitable age for cutting cordwood in unthinned natural stands, and the actual cost per cord of growing it with natural reproduction. Cost of growing as given in Table* 14.

Average conditions of growth.

Age of stand Years	Yield per acre in cords of 160 cord feet of peeled stem wood Cords	Value of stand at $2.00 a cord stumpage	Total cost per acre of growing stand	Profit per acre at any period	Cost per cord of growing timber
20	13	$26	$ 19.53	$ 6.47	$1.50
25	19	38	27.53	10.47	1.45
30	23	46	38.05	7.95	1.65
35	27	54	52.07	1.93	1.93
40	31	62	70.60	loss 8.60	2.28
45	34	68	94.54	loss 26.54	2.78
50	37	74	126.69	loss 52.69	3.42
55	40	80	167.90	loss 87.90	4.20
60	43	86	221.13	loss 135.13	5.14

GENERAL INSTRUCTIONS.

Protection.—It is necessary to protect from fire and cattle, areas which are in process of stocking with yellow poplar, young stands, and plantations of yellow poplar. This species is extremely sensitive to fire, particularly to early spring fire, until the bark becomes thick and rough. In the case of large areas, as of cut-over land, patrol during spring and in autumn until the newly fallen leaves are thoroughly compact and moist, is the most effective method of preventing fires. It is sometimes possible, particularly in the case of small tracts or single coves, to isolate by means of fire lines, but these should never be exclusively relied upon. It is generally desirable to lop the under limbs of tops of felled trees in order to bring the trunks in close contact with the soil and hasten their decay. Unless there is a large amount of pine or hemlock (spruce pine) slash, the piling and burning of brush is not desirable, since it destroys humus. When large tracts are being grazed, it is necessary either to herd cattle to prevent destruction of small yellow poplar seedling, or to fence areas on which the young growth could be injured.

Unless plantations are protected, the destruction of a part of the stand is likely to result in understocking. The results of understocking are: short-bodied and scrubby trees, the stems being set with numerous large knots so that the lumber is low grade; and in spite of the relatively large diameters of the individual trees a low yield per acre.

Elimination cuttings.—In natural stands of yellow poplar on cut-over land there will often be a very large proportion of low grade species. When these are rapid growing and might seriously interfere with the growth of the poplar, or entirely crowd it out, it is necessary to eradicate them. The material which is cut in this manner often will have no sale value, the cutting being made entirely for the benefit of the mature stand. Such cuttings can sometimes be combined with thinnings

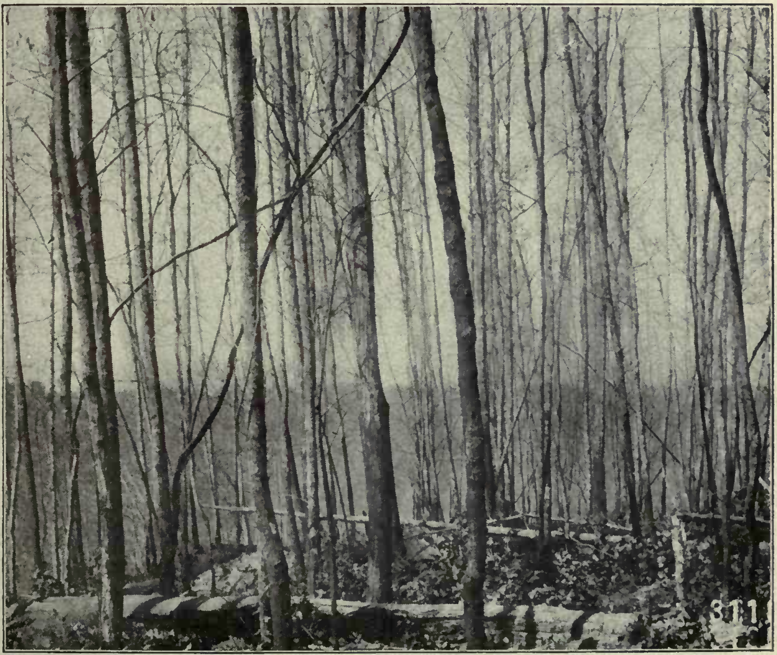


FIG. 7. A pole stand of hardwoods, containing much yellow poplar killed by a severe spring fire. Note sprouts around bases of trees.

Thinnings.—Thinnings are made for the purpose of accelerating the growth of the remaining trees in a stand. They cover two periods. Those which are made in very young stands of sapling and pole size, the result of which, in addition to lessening overcrowding, is the elimination of trees of undesirable species from the stand. The smaller trees with the poorest formed stems should be removed. Thinnings in young stands should be light, but should be repeated as soon as the crowns of the trees have again become so close together that they interfere. The crowns will seldom touch after the trees have reached small-pole size. Thinnings of this character do not retard height growth or materially interfere with the cleaning of the stem of branches. Thinnings in young stands should never be severe enough to permit the development of large branches. (Fig. 8.)

The second period in thinning is after the stand has reached the large-pole stage and the trees, according to site, are from 80 to 110 feet in height. Clear length of stem has already been developed, and but slight additional growth in height will take place. The best trees should be isolated. These will soon form large crowns and rapid growth in diameter will take place. Additional diameter means not only increased volume, but a higher proportion of upper grades. The diameter of the trees is more important than their number. It will be far more profitable to have 70 trees per acre which have average diameters of 20 inches than 160 trees which have diameters of 15 inches. The 20-inch trees have a stumpage value of $3.61 each under an operating cost of $12 per 1,000 board feet, or $252.70 an acre. The 15-inch trees have a stumpage value of 83 cents each or only $132.80 an acre. The yield in board feet is approximately the same in both cases—about 23,000 feet per acre. (See Fig. 1.)

The trees removed in thinning from stands after they have passed the sapling stage, should pay for all thinnings. Even-aged second growth stands have a form of forest which requires thinning in order to develop their maximum yields. It is impossible for lumbermen economically to apply thinnings on a large and rough tract, until a suitable form of forest shall have been developed. But second growth stands, owned by farmers or others who live on their land, even when they are irregular in form, but which are in easy handling distance of a market, can be profitably thinned at any time, although the profits are greater from stands in which a definite form has been secured.

There are many thousand acres of even-aged, second-growth stands in Tennessee which could be profitably thinned, even if no returns were obtained from the thinnings. Table 17 shows the composition and range of diameters of the different species in such a stand.

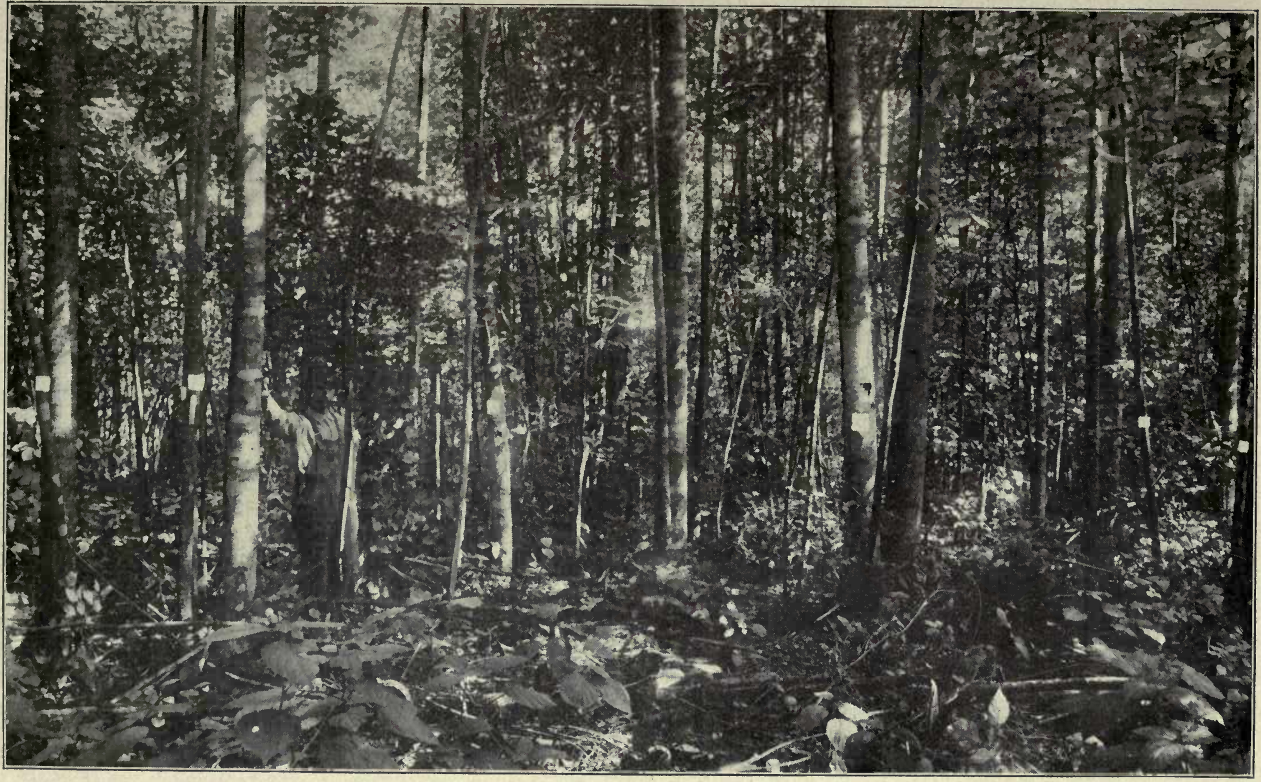


FIG. 8. A 20-year-old stand of yellow poplar, first quality, the larger trees being from 60 to 70 feet high and 9 to 11 inches in diameter. This stand was thinned and cleaned 5 years ago when most of the chestnut, oak and other species which were crowding the poplars were cut out. The stand now consists largely of yellow poplar and is ready for a second thinning. This should be made by removing the marked trees. It is necessary to cut some of the larger poplars whose crowns are being crowded. One such tree is marked for removal in the foreground. The heavy undergrowth of dogwood and other species which are tolerant of considerable shade is noteworthy. (Author's illustration.)

TABLE 17.—*Second-growth on coaled-over land, the stand composed of poplar and locust seedlings, chestnut sprouts, and oak seedlings and seedling-sprouts. Site as good for poplar as for chestnut. Age of stand* 54 *years. One acre. Carter County.*

Diameter breast-high	Poplar	Chestnut	Oak	Locust	Others
1— 3	8	12	..	..	56
6— 9	12	28	8	4	..
10—12	24	36	..	..	..
13—15	20	32	..	..	..
16—18	8	20	..	4	..
	72	128	8	8	56
Total per acre above 9 inches.	54	88	..	4	..

The poplars above 12 inches in diameter are 115 feet high; the chestnut of the same sizes are from 108 to 110 feet high. Such a site is well suited for the production of large sized poplar timber, and the crowns of the poplars, which are still being crowded by the chestnut, should be freed by cutting the latter. This would be a combined thinning and elimination cutting. Had some of the chestnut been removed in successive earlier thinnings, it would have been possible to have forced all of the poplar to diameters above 14 inches. The chestnuts can now be removed for poles, the most profitable form in which they can be marketed, and the locust should be cut, but the poplar should be held until the accelerated growth which followed the thinning begins to decline. (See Figs. 1 and 3.)

BETTER UTILIZATION.

Reduction of waste.—Since the most valuable timber in the trees is in the butt log, stumps of sound trees should be cut just as low as possible. In the case of crooked trees, log lengths should be varied so that there will be no crooked logs or so that the crooks will be near the end of the logs. Sound timber in the top should be used whenever the selling price of the lumber in it, less the discount, exceeds the value of the labor in converting it. This secures the removal of tops which may be a fire menace, without materially reducing profits or stumpage value. As soon, however, as the value of the lumber in a log is less than the cost of the labor to convert it, its removal results in a reduction in the value of the remaining logs of a tree. Consequently, very limby and knotty top logs which will yield not to exceed 25 per cent. of No. 2 Common or better, and the lumber from which would have a net value of $10 per 1,000 feet, after deducting overhead charges, stumpage and trade discounts, should not be removed when labor items, including delivery on cars, amount to more than this.

Where trees are short bodied and low grade, but sound, a large portion of the timber being of unprofitable character, the tree should be held, since some growth is taking place and this, added to the appreciation in the price of stumpage which is rapid in the case of low grade timber (see Table No. 12), will eventually assure the removal of such trees at a profit.

Selling timber in the most profitable form.—The wood of second growth yellow poplar is commonly measured either as logs scaled by Doyle-Scribner rule, or as cords of 128 cubic feet of piled wood with the bark on, or as cords of 160 cubic feet of piled wood with the bark peeled. It is frequently desirable to determine before cutting the most profitable form in which to market small trees. Veneer is generally cut from logs 16 inches and over in diameter, and is measured by the cubic feet of solid wood in the log. There is consequently no difficulty in ascertaining the relative value of logs marketed for veneer stock, and measured by a log scale.

The relative value of small trees of different sizes for pulp cordwood and for saw timber is shown in Table 18. Stumpage values in the table are placed at $1 per 1,000 feet for lumber, measured by Doyle-Scribner rule; and at $1 a cord of 160 cubic feet for wood measured after it is rossed, dried, and racked. To use this table it is necessary to multiply the volumes which are given in the table for trees of each diameter, by the relation of the stumpage at $1 to the actual stumpage price which is offered, using as a basal diameter the diameter breast-high of the average sized tree on the tract. For example: if board measure stumpage were worth $1.50 per 1,000 feet, the volume which is given for the average tree in the board-measure column should be multiplied by 1.50. If the cordwood stumpage measured after peeling were worth 50 cents a cord, the value given of the average sized tree which is under this head should be multiplied by .50. A comparison of the two resultant figures will show in which form the timber could be marketed most profitably.

Table 19 shows the number of trees required to make a cord of 160 cubic feet after they are peeled, split, and dried.

TABLE 18.—*Comparative value of trees of yellow poplar of different sizes for cordwood, peeled, and for lumber (scaled by Doyle-Scribner rule).*

(Based on the average tree.)

Diameter breast-high Inches	Cordwood, 160 cubic feet, measured after peeling, at $1.00 per cord	Saw logs scaled by Doyle-Scribner rule, at $1.00 per 1,000 board feet
6	....	....
7	.04	....
8	.066	.01
9	.086	.014
10	.11	.024
11	.13	.031
12	.163	.05
13	.20	.075
14	.25	.10
15	.32	.13
16	.40	.163
17	.48	.20
18	.52	.243

TABLE 19.—*Number of trees of yellow poplar split and peeled in second-growth stands 25 to 50 years old required to make a long cord of 160 cubic feet; the percentage of bark, and the percentage of waste in stump, top, and bark.*

Diameter breast-high Inches	Number of trees (stem wood only to 3 inches) to a long cord split and peeled	Double thickness of bark at breast-high Inches	Percentage of bark in the stem	Height of stump feet	Percentage of wood lost in stump, bark and top of stem (top used to 3 inches)
7	23.	.9	20	1.3	27
8	15.2	1.0	19	1.3	25
9	12.0	1.5	18	1.4	24
10	9.4	1.1	18	1.4	23
11	7.6	1.2	17	1.4	22
12	6.1	1.3	17	1.4	22
13	5.0	1.4	17	1.5	21
14	4.0	1.4	17	1.5	21
15	3.1	1.4	16	1.6	21
16	2.5	1.5	16	1.7	21
17	2.1	1.5	16	1.7	21
18	1.9	1 5	16	1.8	21
19	1.7	1.5	15	1.9	20
20	1.5	1.6	15	2.	20

PLANTATIONS.

Yellow poplar can be easily and cheaply grown from plants raised in a nursery or taken from the forest or edges of fields and pastures. Seeds cost from 40 cents to $1.00 a pound. There are about 9,000 seeds to a pound. Their vitality, however, is low, it being the exception when more than 15 per cent. of the seed are sound. The seed can be planted either in the fall or in the spring. If planting, however, is to be deferred until spring, the seed should be stratified in moist sand immediately after collection in the fall, and kept in this manner until they are to be planted in the spring. If they are permitted to dry out and then planted the succeeding spring, not only do most of them lie over in the soil a year before germinating, but there is a decline in germinability. Seed should be sown in broad shallow rows 18 inches apart and covered not more than one-half inch. Unless the seed bed is established in the forest, and receives some shade from the surrounding trees, the seedlings should be given a light shade with a screen of laths or brush during the first summer. If the soil of the seed bed is fertile, the seedlings when a year old should be at least one foot high. They will have long tap-roots which must be cut off when out-planted. It is not desirable to transplant in the nursery. While one-year-old plants will usually be used for permanent planting it is possible to outplant the seedling when from three weeks to two months old. The taproot at this age is small and need not be cut. On fertile sites spacing in permanent planting should be six by six feet; on poor sites five by five feet.

Plantations can be made on any sites which have a deep, porous soil, well provided with humus, and neither wet nor extremely dry. Heaviest yields can be expected from sites on which large trees of yellow poplar occurred in the original forest. It is possible, however, to grow poplar in plantations on far drier sites than are naturally occupied by the trees, but it is desirable in planting on such dry sites to mix the poplar with some species like white pine, red oak, white oak, or chestnut, which have a more dense canopy than poplar and will better protect the soil than this species. On moist sites, poplar can be mixed with hard maple, white pine, or basswood. At high elevations in the Cumberland Mountains and in the mountains between North Carolina and Tennessee, poplar can be mixed with white ash or black cherry. Such mixture, however, should be made only on fertile soils, preferably on north slopes. Where there is a good market for locust posts and the locust is not seriously attacked by the borer, this species can be mixed with yellow poplar. The locust can be removed for posts in thinnings, leaving the poplar for the permanent tree.

It is necessary to thin plantations of yellow poplar as the trees become large and crowding takes place. This requirement should be considered in making mixtures and at least a portion of the trees in such mixtures should be species, the wood of which can be profitably used when of small size. In establishing mixed plantations, the different species can be planted in separate rows, or each species can be planted so as to occupy a small group. The cost of planting is cheaper when the species are separated in rows, but the thinnings are easier executed when the species are separated in groups. The groups can be from one-half to one rod square.

It is not necessary that the land should be plowed, but it is necessary that it should be open, and that there should be no growth which will smother or choke the young plants. Plantations should never be established on very grassy sites or beneath thickets or shrubs. In planting cut-over land, this must be kept in mind, and plantations should be only on sites which are open. The growth of the seedling, however, is far more rapid on good sites than on poor sites, and while it will soon overtop brambles and such low shrubs in the rich soil of coves, it is likely to be smothered by them in less favorable localities. Table No. 20 shows the most profitable age for cutting yellow poplar in thinned planted stands, and the cost per 1,000 board feet of growing the timber. The profit shown is the net profit above all interest on the investment, which is calculated at 5 per cent. a year, compounded. There is an additional profit, which is not shown, in the increase in the value of stumpage. If this should be at the rate of 3 per cent. per annum, which is one-fourth of the rate of increase in price during the past 20 years, the investment would earn more than 10 per cent a year, compounded, when the stand is 40 years or more old.

TABLE 20.—*Most profitable age for cutting yellow poplar in thinned planted stands, and cost per 1,000 board feet of growing timber. Interest rate 5 per cent.; value of land $5 an acre; cost of planting $6 an acre.*

				AVERAGE CONDITION OF GROWTH									
	Value of stumpage on basis of present prices			Expenses in producing timber									
							Taxes on						
				Land	Cost of Planting	Protection	Timber		Land				
Age of stand	Value of saw-timber at end of each 5-year period	Estimated value of thinnings at $2 a cord	Value of thinnings and accrued interest thereon at 5 per cent. compounded to end of each 5-year period	Accrued interest on value of land to end of each 5-year period	Cost and interest of each 5-year period.	At 5c per acre a year and accrued interest to end of each 5-year period	Annual taxes at 1 per cent. on a 2-3 valuation of stand to end of each 5-year period	Accrued interest at 5 per cent. to end of each 5-year period.	Taxes at 1 per cent at uniform value, accrued to end of each 5-year period.	Total expenses to end of each 5-year period.	Total value of timber with accrued interest on thinnings to end of each 5-year period	Profit or loss on stand to end of each 5-year period	Cost of growing stand
Years								Per acre					Per 1,000 ft.
20	$ 25	$ 6.40	$....	$8.27	$ 15.92	$ 1.65	$0.16	....	$ 1.65	$ 27.49	$ 25.00	$ 2.49	$4.10
25	45	....	8.17	11.93	20.32	2.99	.30	$ 0.88	2.39	37.91	53.17	15.26	3.11
30	67	10.00	10.40	16.61	25.93	3.32	.45	2.79	3.32	51.97	77.40	25.43	3.11
35	92	....	26.03	22.58	33.10	4.52	.62	6.06	4.52	70.78	118.03	47.52	3.44
40	114	10.00	33.21	30.20	42.24	6.04	.76	11.18	6.04	95.70	147.21	51.51	3.99
45	136	....	55.14	39.93	53.91	7.99	.91	18.51	7.99	128.33	191.14	62.81	4.75
50	155	8.00	70.36	52.34	68.80	10.47	1.03	28.72	10.47	170.80	225.36	54.56	5.69
55	172	....	99.97	68.18	87.81	13.64	1.14	42.45	13.64	225.72	271.97	46.25	6.92
60	186	....	127.56	88.40	112.08	17.68	1.24	60.64	17.68	296.48	313.56	17.08	8.42

COST OF GROWING YELLOW POPLAR IN PLANTATIONS.

Table 21 shows the cost of growing yellow poplar in unthinned plantations on different sites, and the rate per cent. which would be yielded on the initial investment indicated in the table.

TABLE 21.—*Cost per 1,000 board feet of growing yellow poplar in plantations. Interest rate 5 per cent; cost of stocking $6 an acre.*

Age of stand	Value of stand at present prices	Average annual increase in value per acre	Total* expenses in growing timber per acre	Profit or loss in excess of 5 per cent. per acre	Cost of growing stand Per 1,000 feet	Value of stumpage at present prices	Rate of increase in stumpage values necessary to yield 5 per cent. net	Rate of increase in value of stand per acre
Years	Per 1,000 feet					Per acre	Per cent.	Per cent.
	Good conditions I—Value of soil $10 an acre							
20	$4.18	$2.30	$ 37.41	$ 8.59	$ 3.40	$ 46	..	20.0
30	4.80	3.13	73.80	20.20	3.77	94	..	7.4
40	5.34	3.58	137.39	5.61	5.13	143	..	4.2
50	5.44	3.60	244.88	64.88	7.40	180	.6	2.3
60	5.29	3.38	423.00	220.00	11.02	203	1.2	1.6
	Average conditions II—Value of soil $5 an acre							
20	$3.33	$0.85	$ 27.49	$ 10.49	$ 5.39	$ 17	2.2	23.0
30	3.33	1.43	51.01	8.01	3.95	43	.6	9.4
40	4.02	1.95	91.72	13.72	4.73	78	.4	6.0
50	4.52	2.28	161.39	47.39	6.40	114	.7	3.8
60	4.72	2.38	277.17	134.17	9.15	143	1.1	2.3
	Poor conditions III—Value of soil $3 an acre							
20	$3.57	$0.25	$ 23.52	$ 18.52	$16.80	$ 5	8.4	23.0
30	3.16	.83	41.82	16.82	5.29	25	1.7	16.0
40	3.72	1.28	73.81	22.81	5.39	51	.9	7.2
50	4.30	1.60	128.00	48.00	6.88	80	.9	4.6
60	4.59	1.75	218.82	113.82	9.56	105	1.2	2.7

---

*See Table— for detailed statement of elements expense.

Soil value.—The cost of growing yellow poplar in plantations as shown in Table 21 is based on a soil value of $10 an acre for best quality sites, of $5 an acre for average quality sites, and $3 an acre for poor quality sites. These are reasonable values for sites which are in a suitable condition for planting. If the land is situated in a farming section the values of soils which produce yellow poplar, even if the sites are extremely rough, will not be less than these. If it is situated in a cut-over mountainous section where the average value of the soil does not exceed $2 an acre, the sites suited for yellow poplar would embrace only the very best soils—the coves and lower slopes—which would amount probably to less than 20 per cent. of the area of any large tract. One-third of this 20 per cent. might have a growing capacity equal to that given for the best quality sites, while that of the remaining two-thirds would be less. Its relative value consequently would be far greater than that of the other 80 per cent. of the tract. If the land were foul, making it necessary to cut off some of the brush, as would often be the case, this would add to the cost of planting and counterbalance its apparent cheapness.

Cost of planting.—The cost of planting one-year-old seedlings, including the cost of the planting stock as well as the labor, is placed at $6.00 an acre, a low figure, but possible if the work is economically done and if the seedlings are home grown. On the best sites where spacing need be only 8x8 feet (680 trees to the acre) the cost would be less. On poor sites where a spacing of 6x6 feet should be used (1,200 trees to the acre) the cost of planting yearlings should not exceed $6.00.

Yield.—Yield of plantations is calculated on the basis only of thinning stands (page —) since it is doubtful if any plantations will be established except where thinning can be made. The material from thinning is given a value of $2.00 a cord, a high value for the small-sized wood from the early thinning but low for the larger-sized wood from the older stands. Interest is allowed on the value of thinnings of four per cent. net, accrued for each five years.

Interest rate.—A five per cent. rate is allowed on all expenses connected with establishing the plantation and taxes, except in the returns from thinnings, on which only four per cent. is allowed.

Protection.—For the cost of protection and superintendence, five cents an acre a year is allowed. In the case of estates and farmer's plantations this cost can be entirely eliminated. In the case of forest plantations the cost of protection may exceed this item for the first 20 years. It should rapidly decrease, however, with the age of the stand and with succeeding thinnings.

Taxes.—A uniform tax of 1.20 per cent. on the actual soil value ($5 an acre) is allowed for the entire period. The tax on the timber is assumed not to begin until the stand is 20 years old, at which period the stand begins to acquire merchantable value. The actual value at the end of each five years is taken as the assessed value, with a tax rate of one per cent.

Volume V 4 Number 2

APRIL, 1915

THE RESOURCES OF TENNESSEE

Published by the State Geological Survey

NASHVILLE, TENNESSEE

STATE GEOLOGICAL COMMISSION

GOV. TOM C. RYE, *Chairman*

DR. BROWN AYRES, *Secretary*
President, University of Tennessee

CAPT. T. F. PECK
Commissioner of Agriculture

DR. J. H. KIRKLAND
Chancellor, Vanderbilt University

BISHOP A. W. KNIGHT
Vice-Chancellor, University of the South

GEO. E. SYLVESTER
Chief Mine Inspector

GEOLOGICAL CORPS

A. H. PURDUE
State Geologist

OLAF P. JENKINS
Assistant Geologist

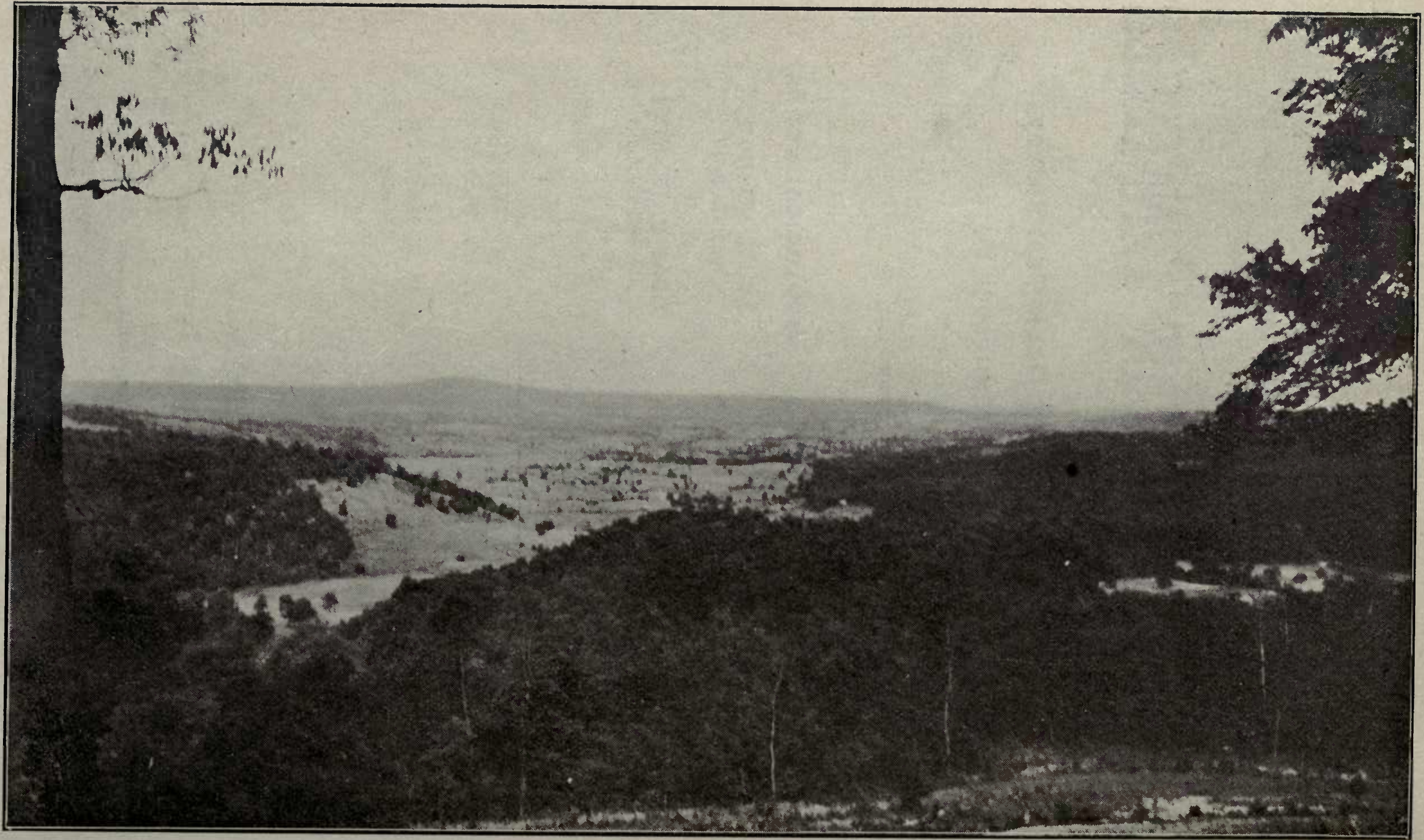
PAUL C. BOWERS
Chemist

J. A. SWITZER
Hydraulic Engineer

R. S. MADDOX
Forester

CONTENTS

Physiographic Influences in the Development of Tennessee............L. C. Glenn
Care and Protection of Forests....................................R. S. Maddox
Two Natural Bridges of the Cumberland Mountains................W. A. Nelson
News Notes.
Publications of the Geological Survey of Tennessee.



Looking westward from Bon Air on the Cumberland Mountains, into the Central Basin.

Corrections

In Vol. V, No. 1, make the following corrections:

Page 27. Figure numbered 2 should be 4.

Page 28. Figure numbered 3 should be 2.

Page 30. Figure numbered 4 should be 3.

Physiographic Influences in the Development of Tennessee

By L. C. Glenn.

INTRODUCTION.

Purpose of paper.—It is not primarily the purpose of the following paper to describe in minute detail the physiographic features of the State, but rather to set forth these features only in sufficient detail to show their relationship to man's activities. The physiographic description will in general be limited to such features and details as bear especially on the development of the State. Perhaps no state is divided into more sharply delimited and strongly marked physical features than Tennessee, and those who desire primarily a description of these features will find them very clearly presented in Safford's *Geology of Tennessee.* Safford's discussion was written before the days of modern physiography, and yet he shows the relation that the physical features bear to the character of the rocks and their structure in a way that could hardly be improved upon by a modern physiographer.

Physiographic regions.—The surface of the State may be divided into six physiographic regions, which are as follows:

1. The Appalachian Mountains, a narrow barrier on the eastern border.
2. The Great Valley of East Tennessee, a broad depression containing a succession of parallel ridges and valleys.
3. The Cumberland Plateau, a broad barrier region.
4. The Highland Rim or Plain.
5. The Central Basin or Plain.
6. The West Tennessee or Gulf Embayment Plain, subordinate to which may be noted the western valley of the Tennessee River and the flood plain of the Mississippi. These regions will be discussed in the order above given.

APPALACHIAN MOUNTAIN REGION.

General description.—The eastern boundary of the State is formed by the crest line of a linear series of ridges that extend from Georgia to Virginia and beyond. These ridges are usually sharply defined, steep-sided, rough and very sparsely settled. They attain heights of 4,000 to 6,000 feet in parts of the course. From these ridges on the boundary line numerous spurs project westward, in some places for a distance of 10 to 20 miles into the State of Tennessee. These spurs are separated usually by steep, narrow valleys, many of which end in secluded coves well hidren among the ridges. The region as a whole is a great barrier that has always limited or prevented communication across it, save in certain favorable places.

History.—The first whites to enter the State from North Carolina were hunters who followed the buffalo and Indian trails across these mountains into East Tennessee. Somewhat later, as settlers began to follow the hunters and explorers, these trails became the routes by which they, with their pack horses, crossed the mountains, and until near the close of the eighteenth century they were the only lines of communication with North Carolina. Just before the close of the eighteenth century a wagon road was built down the French Broad River, which cuts across this wall of mountains in a deep, narrow gorge. Since then a few other highways have been constructed across these boundary ridges, but they are usually steep and rough and difficult to travel, and are not greatly used. A number of rivers rise in western North Carolina and flow westward across these high ridges in deep and narrow gorges that are usually so rough and wild that they have generally been avoided by the few highways that

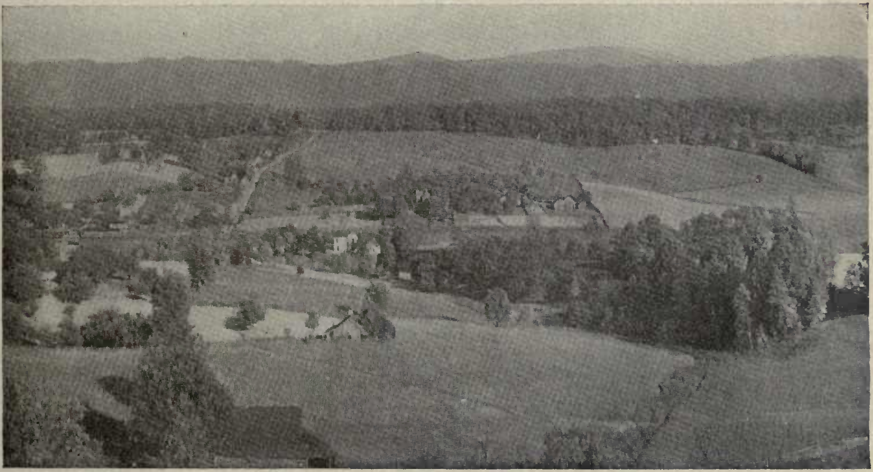


FIG. 1. Typical view across the Great Valley of East Tennessee near Jonesboro. Unaka Mountains in the distance.

also cross them. The road down the Nolichucky River leaves the river before it enters the gorge in the Unaka Mountains, and crosses through Indian Grave Gap at an elevation of over 3,200 feet. The roads down the Big Pigeon, the Little Tennessee and the Hiwassee, likewise leave the rivers and climb across the high ridges on the State line. The only avenues for railway communication from North Carolina to Tennessee are along the river gorges that are cut through the mountains. The first railway to cross this eastern boundary was the one down the French Broad River from Asheville to Morristown, and for years it was the only railway that made the crossing. More recently a railway has been built along the Doe River into, but not entirely across, the western North Carolina mountain belt; another has been built through the gorge of the Nolichucky; another up the Big Pigeon; and another is slowly building up the Little Tennessee. In addition to these, a number of lumber lines have crept from the Great Valley eastward up into the coves. These must either be abandoned when the timber is removed or must remain as local spurlines, since none of them can possibly cross the mountains, except by constructing tunnels whose length and cost would be prohibitive for the amount of traffic they would probably develop.

Barrier effect.—The effect of these mountains has been and must always be to separate the people on either side. They are a very effective barrier and in the early days lead to isolation and neglect on the part of the North Carolina government, for the people who had settled in what was then its western portion. This condition culminated in the virtual secession of the East Tennessee settlers and the formation by them of the short-lived independent state of Franklin. Today while the few roads and several railroads that cross the region permit a certain amount of communication, it is still true that the main line of travel and of trade is not east and west across these mountains, but is northeast and southwest in a direction parallel to them. The Southern Railway, that formerly ran its best trains from Knoxville east to Washington by way of Asheville, now runs them north by Bristol, even though it has to use the tracks of another railway system from Bristol to Lynchburg in order to utilize this better route.

These mountains exert a very definite and positive influence upon the few settlers who are living among them. Those in the more remote coves are isolated, enjoy few opportunities for schools and churches, mingle but little with the rest of the world, and in general have a greatly narrowed horizon. Under such circumstances old social customs and forms of speech, as well as old political and religious beliefs, are preserved long after they have passed away in more progressive communities. Indeed, the entire social and economic setting of these mountaineers is peculiar, and presents certain problems that our sociological workers are now grappling with. It is by no means certain, however, that these people as a class deserve the rather sharp criticism that has sometimes been heaped upon them. They have very much in their lives and characters that is commendable, and for the most merely need certain conditions bettered rather than to have their entire plan of existence overturned. Conditions well suited to other thickly settled communities might not be at all suitable among the isolated farmers hidden away in remote mountain coves.

Resources.—In a few places in these mountains there are deposits of iron, copper, slate or other materials of economic value, and on the surface there grow in most places, magnificent forests of hardwood trees. The soil in many places is too steep to cultivate without serious erosion. There are, however, mountain benches, many coves, and small stream valleys that may be cultivated, and the forested lands may be grazed. Mining, lumbering, and some special forms of agriculture, such as grazing and fruit raising, offer the most promise for the future of this region. The people will remain a sturdy stock.

GREAT VALLEY OF EAST TENNESSEE.

Features.—This is a broad belt 30 to 60 miles wide, that crosses the eastern part of the State from Alabama to Virginia, and consists of numerous long, narrow valleys, separated by narrow, parallel mountain ridges that trend northeast and southwest, in harmony with the general Appalachian structure. The valleys are rolling surfaces, formed by the solution of the limestone that underlies them and not flat, alluvial ones due to flood-plain building by streams, though each valley usually has a stream of some size with a narrow flood plain as a portion of it. The ridges are usually narrow, steep-sided, and for most part run in straight lines. They are formed generally by the upturned edges of the more resistant rocks of the region, many of which are cherty limestones. In some places the ridges consist of shales. In this case they are usually more rounded and less distinctly linear, even though they may be steeper, than when composed largely of chert. These ridges vary in length from a few to many miles, and their ends often overlap each other in such fashion that in traveling across the Great Valley, it is necessary to make many detours around their ends. Travel northeast and southwest parallel to the ridges is direct and easy. As a result the main lines of communication whether by highway or railway, are those paralleling the topography. Railways that cross the Great Valley, such as the Southern from Knoxville to Clinton, or the Louisville and Nashville from Knoxville to Dossett, either make extensive detours in threading their way through the gaps of successive ridges, or resort to long and expensive tunnels where they attempt to go direct.

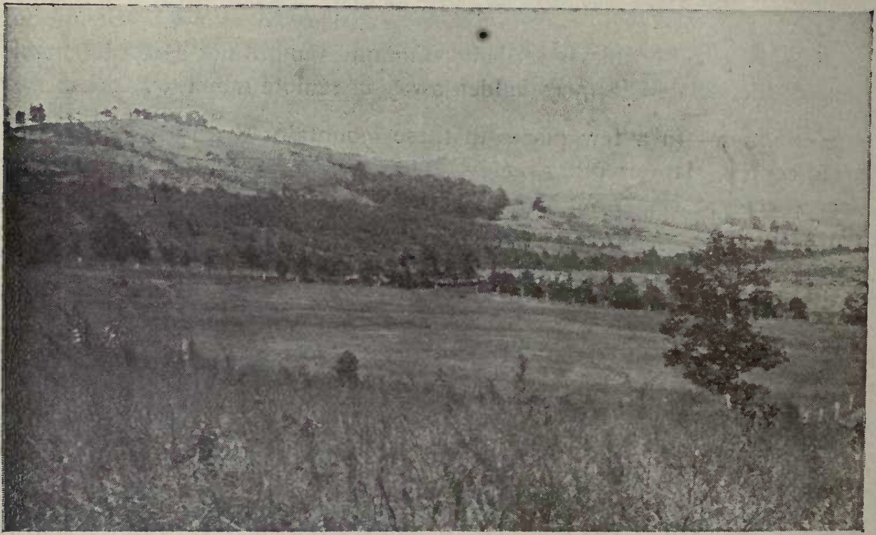


FIG. 2. View from the east side of Missionary Ridge. From one mile south of the Southern Railway tunnel, looking north.

Early settlement.—The first settlers in the Great Valley entered it from Virginia and settled along the main streams, such as the Watauga, the Holston and the Clinch, possibly because the river flood plains were considered more fertile than the uplands. Fish and game may have been additional inducements. The early towns in the region were built on the uplands away from the streams where these were too small for navigation, but on the streams where they were large enough to float the flat-bottomed boats then in use. Greeneville and Jonesboro, for example, were founded on interstream areas, while Kingsport, Knoxville and Kingston, not to mention others, were built on rivers where navigation was possible.

In the larger valleys, farms of large size were possible, and in some places slave owning became profitable. In most places, however, the ridge and valley topography was unfavorable to the development of large land holdings and of plantation life, and smaller farms became the rule.

Slavery did not obtain the same hold on this region that it did in Middle Tennessee. Sentiment on the subject of slavery was greatly divided and abolition societies were founded years before the Civil War. During the war East Tennessee furnished soldiers to both the Union and the Confederate armies, though Union sentiment was predominant. The political beliefs of the region are also a consequence of the same conditions. Most parts of the region are today strongly Republican. Had the surface of East Tennessee been such as to make slavery universally profitable, its history before, during and since the Civil War would have been far different from what it has been.

Types of civilization.—Agriculturally, the valley portions are much more desirable as a rule than the hill portions, and through the principle of the survival of the fittest there has come about a slow differentiation among the people as a result of which the more thrifty and progressive occupy the fertile limestone valleys, and the less energetic have been pushed into the poorer lands of the shale hills and chert ridges. This differentiation once established tends to perpetuate itself, and we find in some places the contrast between the peoples in the valleys and back in the hills very sharply drawn and strongly marked. Needless to say this condition of affairs brings with it certain problems of a social and economic nature.

The wealth and variety of the mineral resources that have been made accessible by the upturning of the rocks of the region, together with other natural advantages, such as the proximity of coal, forest materials and water power, make possible the development of a greatly diversified urban industrial life.

This valley region, cut off from free communication both east and west, has its natural outlet northeastward into Virginia and southward and southwestward into Georgia and Alabama, and commercial and social ties and interchange of people and ideas must always be chiefly in these directions.

CUMBERLAND PLATEAU.

Features.—This division forms a belt 30 to 50 miles wide that extends entirely across the State from Kentucky to Alabama. Its surface has an average elevation for most of the area of about 2,000 feet above sea level, though its culminating points rise to more than 3,500 feet. Its eastern edge is well defined, but its western edge has been made very irregular by the headwater erosion of the streams that rise on its western margin. The general surface of about five-sixths of the plateau is a gently rolling one underlaid, for the most part, by a massive sandstone, but here and there the surface is formed of shales that are in places interbedded with the sandstones. That portion of the surface, however, which lies east of the Cincinnati Southern Railway is not properly a plateau, but is a complex maze of sharp-topped ridges and deep-cut, narrow stream valleys, formed on flat-lying shales and sandstones, by vigorous stream erosion.

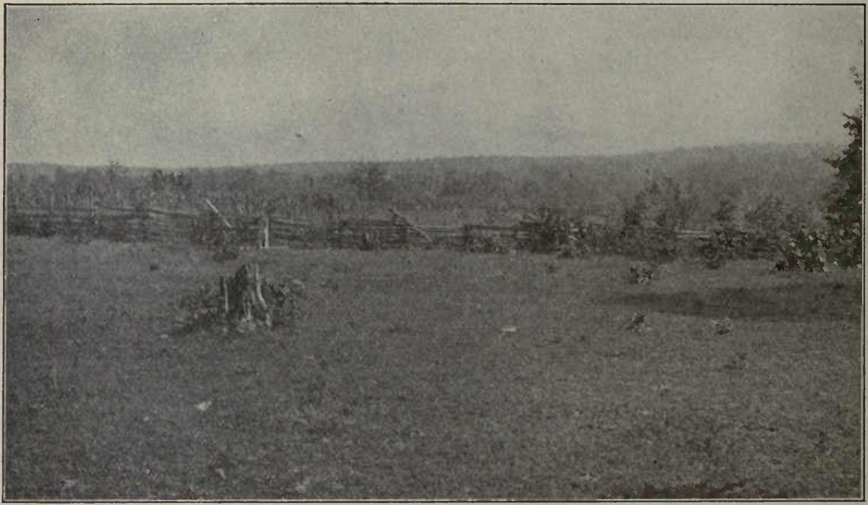


FIG. 3. Cumberland Plateau, in Cumberland County.

The larger streams of most of the plateau are sharply cut beneath the general surface and many of them flow in narrow gorges 300 to 500 feet in depth, the valley walls in many places being made of precipitious cliffs that may be in extreme cases 100 to 200 feet in height. This is particularly true of the northern portion of the plateau west of the Cincinnati Southern Railway in Pickett and Fentress counties, and is true in a somewhat less degree of many other parts of the plateau as well. Further, the southern half of the plateau is deeply cleft longitudinally by a long, narrow, straight valley, occupied by the Sequatchie River. The middle portion of the plateau in the vicinity of Crab Orchard, Crossville, and Monterey, is less dissected by stream gorges than elsewhere.

Barrier effect.—The eastern margin known in the southern part as Walden Ridge, and in the northern part as Cumberland Mountain, is itself a steep-walled barrier that is broken by but few gaps that permit easy access to the plateau surface beyond. In addition to this, the plateau as a whole must be considered as a broad barrier, separating Middle and East Tennessee. The northern half of it, as has been said, is a maze of sharp-topped ridges and deep, narrow valleys in its eastern part, while its western part, although the general surface is almost flat, is broken by many deep, narrow stream gorges, so that it is not possible in this section to establish easy means of communication across the plateau. The southern portion as far north as the head of Sequatchie Valley, is also difficult to cross, because of this valley. There is left, consequently, only a relatively narrow middle belt across which communication east and west may be established with any facility whatever.

In the early settlement of the State, the first immigrants to Middle Tennessee passed around the plateau to the north, through Cumberland Gap, and thence followed down the Cumberland River to the Nashville region, or embarked on the Tennessee River in flat-bottomed boats and passed around and through it to the south through northern Alabama and across West Tennessee into the Ohio, and up the Cumberland to Nashville. For some years after Middle Tennessee had become a permanent settlement, there was no road across the Cumberland Plateau. That region was owned and inhabited by roving Indians and was full of perils for the traveler. A military road was first opened across it in 1787, and in 1799 another one was opened along a somewhat better route some 10 to 20 miles south of the first one and roughly parallel to it. This latter road passed through the gap where Rockwood now stands and by where Crab Orchard, Crossville and Monterey now are. For some years after these roads were opened it was customary for travelers to wait at the eastern side of the plateau until a considerable number had gathered, when they were escorted across it by a detail of soldiers, so great were the dangers of the journey. Even today one may often travel in certain sections of the plateau five or ten miles without seeing a clearing or a habitation, and in eastern Fentress and Pickett counties there are many square miles without an inhabitant. The country is so rough and wild that it has always been popularly known as "the wilderness". It is perhaps more nearly a wilderness in the true sense of the word than any equaled sized area east of the Mississippi River today.

Railways.—For years the only railway connection between Middle and East Tennessee was through the break in the plateau on the southern margin of the State where the Tennessee River cuts its way westward and southwestward across it. This railway, the Nashville, Chattanooga and St. Louis, long enjoyed a monopoly of transportation between these otherwise separated sections, and was largely instrumental in the development of the city of Chattanooga at the eastern terminus of this crossing. Efforts were made for years to establish railway communication across the plateau proper, but these were successful only in very recent years, when the Tennessee Central was finally completed across the middle section of the plateau through Monterey, Crossville and Crab Orchard to Rockwood, following closely the route of the better of the two roads of pioneer days, and utilizing almost the only practicable route for a trans-plateau railway. Notwithstanding this, it is greatly handicapped by heavy grades on the east and west margins of the plateau.

Resources.—The soils of the plateau are as a rule thin and sandy, and yield, under the ordinary careless methods of cultivation, only scanty crops. They are, however, under skillful management, capable of much improvement. Grazing and fruit growing are among the most promising agricultural pursuits, but the region can not attain its best development until radical improvements are made in the methods of agriculture usually practiced, and these improvements are matters of slow introduction. Over most if not quite all of the plateau slavery was unknown, and the inhabitants cared nothing for it and had little or no interest in the problems that grew out of it. During the Civil War, they either remained at home, or, if they entered the contest, they divided along lines of cleavage made possible by the existence of old family or neighborhood grudges and feuds, and a good part of the fighting was of a local or guerrilla character between bands of so-called home guards. The passions thus engendered lingered for a time but have since died away, and the feud, as an institution, can hardly be said to exist in the Cumberlands today. Moonshining is prevalent in certain communities, but is by no means universal, and the moonshiner is not usually the desperado that the reporter and novelist usually picture him to be.

Social conditions.—The population in some of the plateau counties is practically at a standstill. Houses are often so widely scattered that the inhabitants are greatly isolated, and suffer from the many effects of such isolation. Such conditions make for monotony in life and prevent development along many lines that are possible only in a more thickly inhabited country. Schools, churches, roads, villages and other features of community life are but poorly developed. Living conditions in many cases are correspondingly primitive.

Present conditions are complicated in part of the region by the fact that much of the land within the past few decades has passed into the hands of large companies that have purchased it for the coal and timber. In some cases these companies permit and even encourage the original inhabitants to remain upon the land, on what practically amounts to a system of free tenantry, since they consider their presence desirable for the protection that they may afford against forest fires and depredations by timber thieves or other trespassers, as well as to furnish a source of labor for the operation of mines, logging camps, and lumber mills. In some other cases, however, the policy of the large landowners has been to encourage the original inhabitants to remove from the tracts and in such sections their former homes have gone to decay, their small mountain fields are growing up in forests again, and in a few decades almost all signs of civilization will have disappeared.

Needs of the region.—The future of this region offers most promise through the gradual introduction of better methods of agriculture and the encouragement of stock raising, along with the introduction, probably, of thrifty farming classes from the better sections of Europe, if such can be obtained. The further development of the coal and timber will give employment to the residents and will bring other labor into the sections so exploited, yet such labor does not generally add materially to the permanent prosperity of a region. The population around a logging camp or a lumber mill is too often a shifting one, and usually disappears when lumbering operations are over. Mining camps exercise little or no influence upon the general agricultural development and prosperity of the community, since the energies of their inhabitants are concentrated underground in the development of the coal that is being mined.

HIGHLAND PLAIN.

General description.—This physiographic unit is somewhat complex and is difficult to define in simple terms. From the Cumberland Plateau it stretches westward approximately to the Tennessee River, where it crosses the western part of the State. From an elevation of about 1,000 feet on the eastern border the surface of this plain slopes gently westward to an elevation 600 to 800 feet. In Middle Tennessee, in the very heart of the region thus included, the rocks which elsewhere lie horizontal beneath the plain have been slightly uparched into a low dome from which erosion has eaten out an oval basin 60 to 80 miles wide and 150 miles long, with a surface 300 to 400 feet below the general level of the encircling Highland Plain. This plain is in consequence more usually known as the Highland Rim, a term, however, which ignores the true nature of the highland surface as a plain that in many places is well developed and of broad extent, as for instance, about Tullahoma, McMinnville, Clarksville, and Dickson. The edges of the rim surrounding and overlooking the Central Basin are usually intimately dissected into steeply-rounded hills and spurs that form one of the roughest parts of the Highland Plain. Another portion of the plain that is well dissected by streams is the part just east of the Tennessee River in Hardin, Wayne, Perry and adjoining counties. Erosion here has usually been not more than 100 or 200 feet in depth, and even the worst eroded part of the region presents no such obstacles to travel and free communication as are presented by the deeply dissected portions of the Cumberland Plateau.

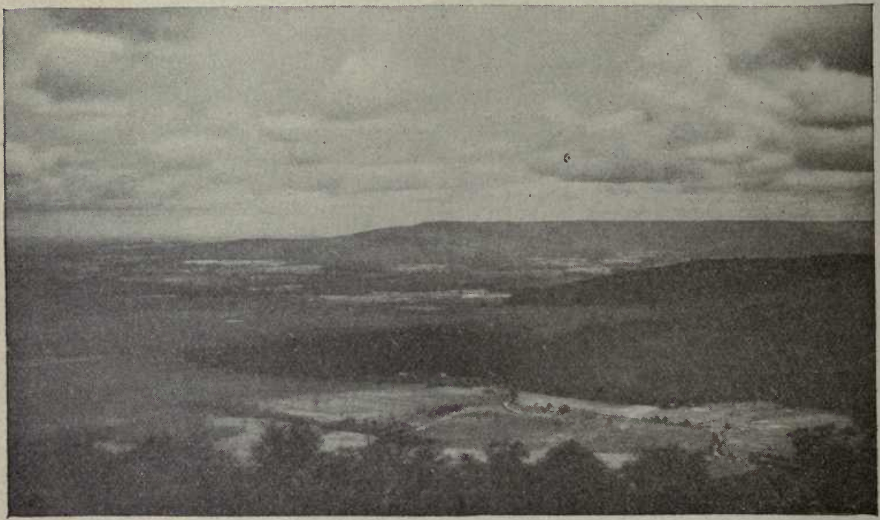


FIG. 4. View from Sunset Rock, Monteagle, looking north. Shows spurs from the Cumberland Plateau, jutting out on the Highland Plain.

Influence of geology on topography and soil.—The general surface of the Highland Plain is somewhat complex in its geology, and this has resulted in certain differences in topography and soil that have had a more marked influence in the development of the plain than any other. A part of the surface is underlaid by the St. Louis limestone and has the rolling topography usually characteristic of limestone solution surfaces. It also has the good soils that are usually an additional characteristic of such regions. A second part of the plain has a siliceous shale as its underlying rock and has in consequence a thin, siliceous, silty soil whose surface is more nearly flat than the limestone area, and is in some places poorly drained and infertile. A third portion of the plain has a surface composed of flat-lying beds of sandstone that have resisted erosion more than the surrounding rocks, and in consequence stand above these rocks as flat-topped ridges or mesa-like areas that usually have a poor soil and are generally uncleared and uninhabited. Such areas as these form the ridges between McMinnville and Livingston. In other parts of the Highland Plain they either do not occur or are of little importance.

Settlement.—The settlement and subsequent development of the Highland Plain have been largely controlled by these soil differences. In areas of good limestone soils it has been but natural that the inhabitants should become more prosperous and progressive than those in areas of poorer shales and sandstones. In fact many areas of these poorer soils have an exceedingly scant population even today, while the more fertile limestone areas are thickly settled and prosperous communities. The growth of the towns of the region has depended, like the general growth of the population, upon the fertility of the soil of their immediately vicinity and their relative size and prosperity is at once a result and an index of the general fertility of the particular section in which they are each situated, since their prosperity depends almost entirely upon the agricultural resources of the surrounding country.

The different soil conditions largely determined the past economic and political history of the section, governed the development of slavery in it and in consequence determined the allegeance of the inhabitants during the Civil War, some to the Confederate, and some to the Federal cause. In politics the region is predominantly Democratic.

Future of the area.—The future development of this region must show, as its past has shown, differences in development that are traceable primarily to differences in soil fertility. Some sections will always be more prosperous than others. Improved methods of agriculture have, however, shown within recent years, that it is possible to handle the soils of the poorer areas in such manner as to produce excellent crops. The general adoption of these improved methods must lead to increasing prosperity in such areas, and these will tend to minimize the social and industrial differences that now exist between the more and the less fertile sections of the Highland Plain. The future of the region is almost entirely agricultural since there are, generally speaking, no mineral deposits of great importance save in certain sections of the western portion where, locally, iron ores are abundant. Much of the timber of the region has been cut and the tendency is, as everywhere, toward its further destruction. This section is capable of supporting a very much larger population than it now has, under conditions that will vary from medium to good, and there is no inherent reason why it should not as a whole become quite a prosperous section of the State.

CENTRAL PLAIN.

Origin.—This division of the State forms a basin that has been produced by the erosion and unroofing of the gentle dome mentioned in the description of the Highland Plain. It is 50 to 60 miles in width and about 100 miles in length, with its longer axis extending somewhat northeast and southwest. Murfreesboro is a few miles southeast of the center of the basin and Nashville is situated near its northwestern margin. The general surface of the plain is some 300 to 400 feet below that of the surrounding Highland Plain.

Drainage.—Cumberland River flows into the basin or plain from the northeast, and after receiving numerous tributaries within the basin leaves it by a relatively narrow groove cut in the northwestern part of the surrounding Highland Plain. Harpeth River rises in the Central Basin and flows northwestward out of the basin in a similar valley cut in the Highland Plain. Duck and Elk rivers drain the southern part of the basin and likewise cut through the encircling highland. It is evident that all of these streams were in existence before the basin was formed and that they cut their way downward through the rocks of the encircling rim as the central dome was unroofed by erosion and the basin slowly developed. In no other way can one explain why rivers flow from a lower land across a higher one. It is well known to geologists that the Central Basin was never a lake as some have supposed, and the streams that leave it could never have been outlets by which the supposed lake was drained. It would have been exceedingly improbable that a lake would ever have four outlets and much more improbable that each would have cut down at so even a rate as to have all survived the draining of the lake.

Surface.—The general surface of the Central Plain is a gently rolling one produced by stream erosion and solution on limestones, whose doming is so gentle that they are almost flat-lying. The soils of the region are the insoluble residue left by the solution of the limestone. Where this solution has been more rapid the soils form a thick surface mantle, but where the limestones are more cherty and hence less soluble, the soils are thin and the surface is glady. A portion of the limestones contain a considerable percentage of phosphatic matter, and their solution has left a soil unusually rich in the form of plant food. The soils of this phosphatic type attain their best development in the region of Columbia and Mount Pleasant, and this is the secret of the high, natural fertility of that and some of the other portions of the Central Basin.

The bounding margin of the Central Plain or Basin is not a simple and smooth slope, but on the contrary is usually very irregular, since it has been formed by the headwater erosion of streams that are eating into the surrounding Highland Plain and enlarging the area of the Central Basin at the expense of this upper plain. The result has been an irregular, crenulated margin such as may be seen at almost any point around the basin.

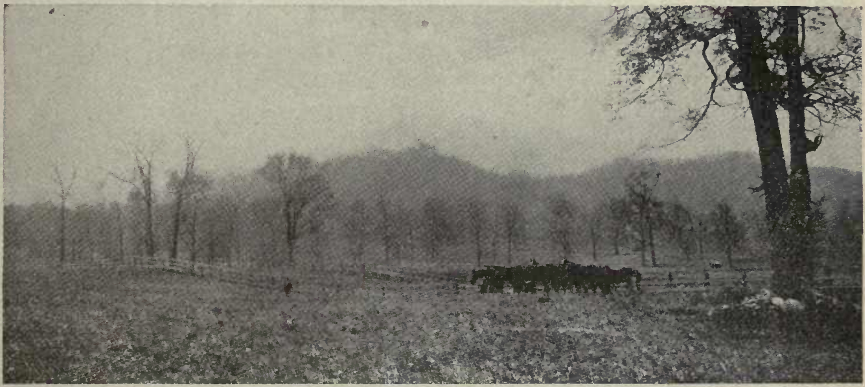


FIG. 5. Central Plain, with Highland Rim in background.

Conditions almost everywhere in the Central Plain have been good for settlement and development. It may be looked upon indeed as a region of physiographic liberty where man might settle practically anywhere and develop according to his own inclination. There has been comparatively little in the way of natural restraint or compulsion to determine and direct man's activities in the development of the Central Plain. A good farm or a village might be established almost anywhere. Perhaps the nearest approach to guidance in the region has come from the existence at a few places of geological faults or breaks in the rocks up along which salt waters have for ages found their way to the surface, producing salt springs or licks. These springs became the meeting place for the wild animals of the region in their search for salt, and in consequence attracted the Indians and later white hunters, fur traders, and finally the pioneer settlers. Nashville, for instance, owes its location chiefly to the existence of a large salt lick where the French, as early as 1713, established a trading post. The presence of bluffs along the river was probably an additional, though subordinate, factor in determining its location.

Development.—Most settlements in the region were largely the result of chance or individual preference. Perhaps the existence of a large spring was more nearly a determining factor than any one thing; while a chance mill or some small stream or a crossroads store with the blacksmith or cobbler's shop that often accompanied it, may have formed a neuclus for the development of a town. Most towns of the Central Plain show scarcely more important determining factors for their location than these. The growth of the towns of the region has depended for the most part on the fertility of the immediately surrounding country, and upon the transportation facilities and proximity of neighboring towns.

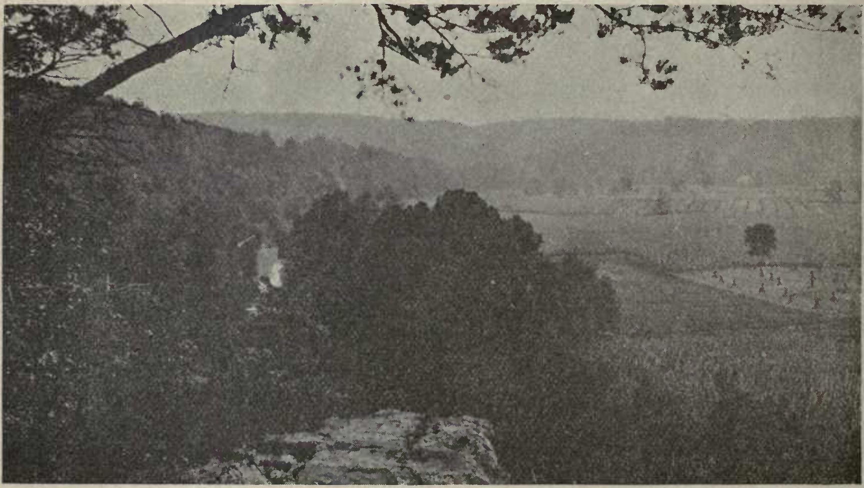


FIG 6. Marginal view of the Highland Rim and the Central Plain.

The development of highways presented no difficulty on such a rolling to nearly level surface and roads were built wherever desired. The same thing has been true of railways. They have been constructed without difficulty across any part of the Central Plain. They have, however, met with considerable difficulty when attempting to leave this plain, since it has been necessary for them to climb some 300 or 400 feet in order to reach the level of the surrounding Highland Plain. The Louisville line of the Louisville and Nashville Railroad, for example, has heavy grades where climbing out of the basin near South Tunnel. The Evansville line of the same road for years operated a three or four per cent. grade between Baker and Ridgetop at great expense for maintenance, and with constant danger of having run-away trains. It has recently rebuilt a number of miles of track there and constructed a tunnel almost a mile long at an expenditure of several millions of dollars, in order to overcome the physical obstacles presented by this rim. The Tennessee Central Railroad leaves the basin to the west by following the valley of Cumberland River, and so avoids heavy grades. To the east of Nashville it climbs out of the basin by a long heavy grade. The Nashville, Chattanooga and St. Louis Railway has expended large sums of money in decreasing the heavy grade on the western edge of the basin between Pegram and White Bluff, and its main line to Chattanooga has a similar steep grade just north of Tullahoma.

The development of civilization on the Central Plain has probably been more homogeneous than elsewhere in the State. Conditions there on the average have been better than elsewhere, and so there was in early days a rather more rapid settlement of the region and development of culture and wealth. Land holdings were often large, and farming on an extensive scale by slave labor was usually profitable. The sympathies of the people were in consequence strongly southern, and in the Civil War they entered the Confederate Army. Since then the region has been Democratic in political faith and conditions are such as to warrant the prediction that it will remain so.

So far as physical conditions go there is no adequate reason for any marked difference in political faith or social or industrial life in the Central Basin. Practically all interests and pursuits are similar, the soils and products are largely similar, and hence all phases of community life may be expected to be much alike. Such political differences as have marked some sections of the region in the past have been due to the strong personality of some political leader whose influence and personal following have swayed the votes of his county or section at certain times in some special direction. These differences have usually disappeared soon after the leaders that caused them have ended their political careers.

The future of this region will be one of continued homogeneous development under very favorable natural circumstances. This development will be most largely agricultural and will be pitched on a relatively high plane.

WEST TENNESSEE PLAIN.

General character.—This is a part of the Gulf Coastal Plain which reaches its northern limit in southern Illinois. The eastern edge of this division may for the present purpose be taken as the Tennessee River in its northward course across the western part of the State. The plain slopes gently westward from an elevation of from 500 to 700 feet on its eastern margin to an elevation of 300 or 400 feet, where it overlooks the Mississippi flood plain. Its surface is a gently rolling one that becomes somewhat broken along the main streams. It is distinctly hilly along its eastern margin facing the flood plain of the Tennessee River, and its western one overlooking the flood plain of the Mississippi. The streams that drain its surface head near the Tennessee and flow westward into the Mississippi. They have cut their channels down to low grades, flow sluggishly in meandering courses, and have usually developed flood plains from a half to several miles in width. Owing to their low grade, these flood plains are usually swampy, and one of the present day problems of the region is the drainage and reclamation of these swampy lands. The upland soils of the region are either sandy, loamy, or clayey, and the distribution of the soil types is dependent upon the various geological formations of the region. These outcrop in belts whose general course is north and south. The sandy soils may be, according to circumstances, either fertile or infertile. The loams are usually fertile, while the clays are usually poor.

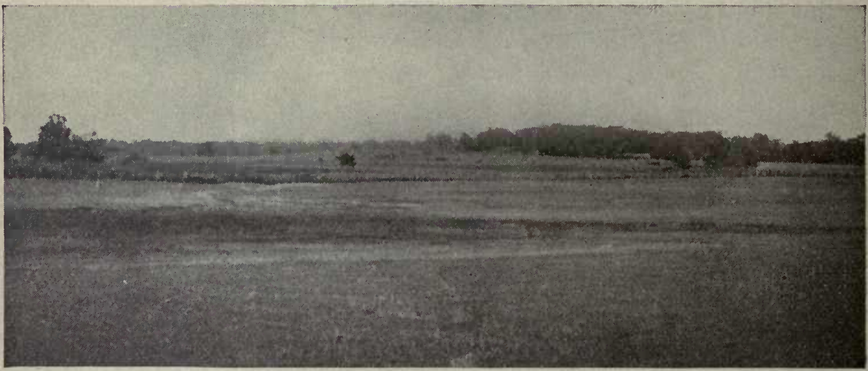


FIG. 7. Characteristic view in West Tennessee.

Settlement.—The settlement of the country has been confined to the uplands away from the swampy flood plains. Farming on an extensive scale became the rule wherever the soils were good, slavery and cotton became features of the life. The slave owners were of course southern in their sympathies, and have been Democratic subsequently in their political faith. It is of interest, however, in this connection to note that a belt of sandy and clayey soils in parts of Hardin and McNairy counties was not favorable to large land holdings and slave labor. Farms in this section were usually smaller and slave labor was not profitable. During the Civil War the inhabitants largely went to the Federal Army, and are in political faith today largely Republican.

Roads in this region have liberty to go practically anywhere, the only obstacles being the swamps along the larger streams. Railways in like manner may be located wherever desired, and towns have grown up with little or no physical restraint as to their location. Chance, or at least other features than those due to the physiography of the country, have been responsible for their location, and their subsequent development has depended partly on the soils of the vicinity and partly on the development of railway communication.

Along the Mississippi, there is usually a flood plain of some width between the stream and the edge of the upland. At three points, however, the river swings against the upland on the eastern side of its valley and has formed bluffs. Towns known as Fulton, Randolph and Memphis were early founded on these three bluffs. Of these, Memphis soon gained an advantage because of conditions that were largely fortuitous, and as a result of its early vigorous growth has attained an ascendency that has enabled it to completely overshadow the other two.

The future of the West Tennessee region should be that of agricultural prosperity. There is already much good agricultural practice, and with further improvement of conditions in farming, the development of better roads, the drainage of the river swamps, and the further extension of truck and small fruit farming, there should be an excellent basis for permanent community prosperity. There are, however, in the region just enough lands that are naturally poor to give a semblance of excuse for local thriftlessness, and so we may expect for years that backward communities will exist locally in the region.

WESTERN VALLEY OF THE TENNESSEE RIVER.

In its lower course the Tennessee River flows north across the State and has cut a valley usually several miles in width to a depth of 300 to

500 feet beneath the upland plain on either side. Much of this valley is above the reach of ordinary floods and it is largely cleared and farmed, though there are parts that are low and swampy.

THE FLOOD PLAIN OF THE MISSISSIPPI.

Except at the three bluffs above mentioned, there is a variable width of flood plain between the western edge of the upland plain of West Tennessee and the Mississippi River. Near the banks of the river, this flood plain is high enough to remain above water in all but the highest floods.

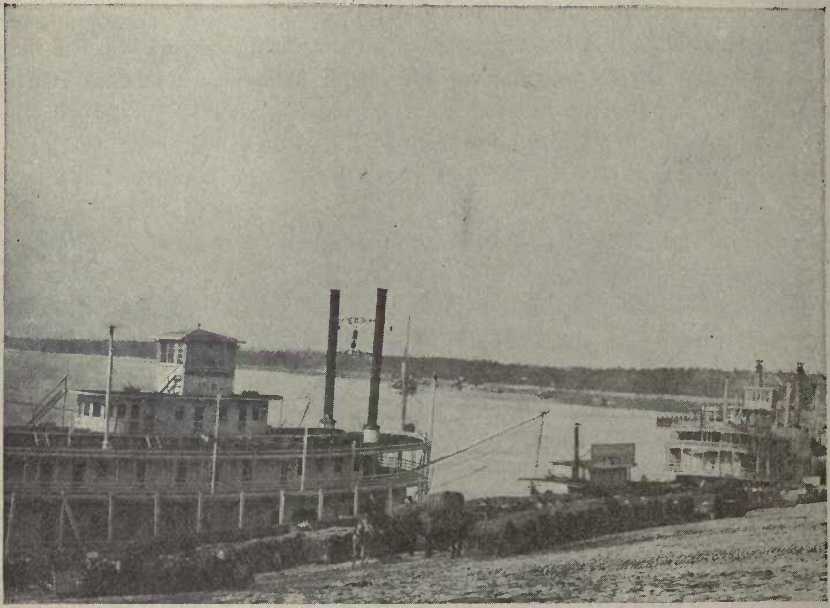


Fig. 8. View of the Mississippi River at Memphis.

Much of this part is cultivated. Farther back from the river the elevation is less and the surface is frequently flooded. It is poorly drained and swampy and is not cleared. With the perfection of the levee system and the drainage of the lower parts, this rich alluvial land should produce immense crops and support a large population.

THE THREE GRAND POLITICAL DIVISIONS OF THE STATE.

The features of the State lend themselves easily to a three-fold division for political purposes that has been long recognized and observed. The division is into East, Middle and West Tennessee. The line separating the East and Middle divisions crosses the Cumberland Plateau so that it is divided somewhat equally between them, while the line separating the middle and western divisions is approximately the lower or northward portion of the Tennessee River. East Tennessee is Republican in politics and is interested in diversified agriculture, mining and manufacturing, while Middle and West Tennessee are Democratic politically and interested primarily in agriculture. The two latter divisions with their common politics and similar, though by no means identical, interests, usually dominate in political matters.

In early days there was a land office and a treasurer for each of these three divisions. The Supreme Court still sits in rotation in East, Middle and West Tennessee. There is a state normal school for each of the three divisions and a state asylum for each division. In the constitution of political boards and committees it is usually specified that equal representation be given to each of these three divisions, so that in many ways the State comprises three separate communities more or less distinct and different from each other, and yet united under one system of government.

GENERAL PREDICTION.

It is always hazardous to play the role of prophet, but a few general conclusions would seem warranted from the facts at hand.

From the diversity of its soils and its surface features and the stimulus of altitude, climate, and the partial obstacles to free communication that obtain in the valley region of East Tennessee, the development of civilization there in the future should produce our highest type of progressive citizenship, marked preëminently by individuality and independence in thought and action, and with more diversity of industrial activity than any other part of the State. Its people should naturally be more nearly radical in their views than in other parts of the State, and might be classed as the future radical progressives of Tennessee.

Middle Tennessee should develop the highest type of conservative cultured citizenship,—a citizenship more inclined to be content with the conditions and institutions as they are and that will take its religion, its politics, and its general outlook on life from a conservative instead of progressive or radical standpoint. It will be more nearly the holding ground for older ideas and its people may be denominated the future conservatives of the State.

West Tennessee is more nearly like Middle Tennessee than East Tennessee in the physical conditions that must influence and largely determine its future development. Consequently the type of civilization and citizenship to be developed there in the future should take much the same trend that will characterize Middle Tennessee.

Of the cities it is even more difficult to hazard a prediction. Knoxville has the natural resources, both mineral and others, that should make it a great manufacturing city. It is, however, hemmed in by the Appalachian Mountains on the east and the Cumberland Plateau on the west so that its industrial and commercial communities must always be confined to the outlet northeast and southwest along the Great Valley.

Chattanooga has slightly greater advantages in its wealth of natural resources, particularly iron and coal, than has Knoxville, and while it has the same commercial outlets northeast and southwest along the Great Valley that Knoxville has, it has, in addition, a westward outlet toward Middle Tennessee, and an eastern and southeastern one through northwestern Georgia, around the southern end of the Appalachians, and it would, in consequence, be picked as the future first city in the Great Valley of East Tennessee.

Nashville, in its future growth, should normally partake of the characteristics of the inhabitants of Middle Tennessee, and may be expected to build along conservative lines, with nothing radical in its industrial or commercial life. This development should, moreover, show a positive influence from the educational interests that are centered in the city.

Memphis, from its location on the great river, its railways and the large tributary territory, is destined to be the great commercial center and probably the wealthiest city of the State, just as Knoxville and Chattanooga will be the greatest manufacturing centers.

Care and Protection of Forests

By R. S. Maddox.

Need of forests.—We can not overestimate the value of forests. They are a necessity. Without them human beings could scarcely exist, because they play such a part in the conservation of our water supply, and because they are producers of lumber and other forms of wood so indispensable to man; in fact, forests may be said to make conditions on earth possible for man's existence. They are cooler in summer, and warmer in winter than bare land, and thus help to make climate more endurable. They break the force and violence of wind. They help to hold the rainfall for a gradual seepage into the ground from which it reappears to feed our springs and streams. They are a source of supply from which man has always been drawing, a reserve which he has too long left uncared for, a gift which he has too often considered a spoil for plunder. Much damage has resulted from their destruction or abuse. The cleared land just as easily and freely pours the rainfall down the slopes, as the well protected, wooded area prevents it from running off. Land unfit for cultivation, and which should have been kept covered with trees, is a great contributor of soil to the floods of water that rush over it. It is like a vine with its tendrils cut off, having nothing with which to hold. If it has been cut over, with the brush and trash left on the area, these furnish excellent fuel for the forest fire that runs through it to burn off everything.

Care of the forests.—The importance of caring for and protecting the forests and forest land of Tennessee can not be emphasized too strongly. They are disappearing from lack of proper use and protection. Too great quantities of timber can not be cut continuously without exhausting the supply, and much land that should be left for timber production is cleared for cultivation. Not enough care is given to land already tilled. When one area becomes washed and worn, another piece of woodland is cleared to fill its place. A big per cent of the land used for farming will last only a few years under the present system of cultivation, and it seems that our woodlands are doomed to supply a never-satisfied want for more land to take the place of that which is being discarded as unfit for further farm use. Forestry and farming come close together and every farmer of the State should be a practical forester.

It takes a long period to grow forests of big trees, but they may be cut down and used, or wasted, in a comparatively short time. It is likely that the future crops of trees will be harvested before they reach near the age of the old stands of virgin timber. However, through some method of regulating the cut, or for the express purpose of securing certain kinds of clear lumber, the trees may be left to grow to a large size. But whether trees are cut in the future at an earlier age or not, it is important always to have plenty of them in the right places and well cared for.

It takes only a few months to grow and harvest ordinary farm products, such as cotton, corn and wheat. In fact the whole work of producing each crop is of short duration. The farmer plows his land, plants, cultivates, harvests and markets his crop in the same year. His labor produces a quick return. His sheep, cattle, horses and hogs are ready for market in a comparatively short time, say from one to five years. But in contrast to these short time productions of the farm, is timber, no less a farm product because of the comparatively long time it takes to mature. Nearly every landowner in the State has his wood lot or "woods" as it is generally called. He secures from his crop of trees such materials of wood as are necessary for his comfort and convenience. If he cuts off a portion of his wood lot for fence rails, posts, fire-wood or lumber, he may see a fine crop of young trees come back to take the place of the old ones. Likely he will not live to see them grow to a stand of large mature timber.

The farmers of the State own a very large amount of the woodlands of Tennessee, and practically all the rest belong to other private individuals, companies and corporations. From them must come a great help in taking care of, protecting and perpetuating the forests and timber supply. One may say he has enough to last him his lifetime, which is doubtless true. But that is not the question; after him there are others coming who will need and can not do without wood, not to mention any of the other benefits of the forest.

The timber of the State was once very abundant, and the population relatively small. Nature has furnished a supply ready at hand which had required no effort from the settler to produce. He simply took it over as a natural right and used it pretty much as he pleased in his limited way. Markets were hard to reach, railroads few or none, the waterways little used, and therefore the amount of lumber reaching the markets was small. But now since the population has increased, and railroads and water transportation have so developed, the heavy demand for lumber has rapidly drained our forests until we are under obligations to take care of what remains of them. The people need more and better timber and they can not afford to draw recklessly upon the present stand. The careless, wasteful method of handling it must become a thing of the past in order to supply the constant demand and check the rapidly growing scarcity of lumber. It will take intelligent thought followed by intelligent action, to make the forests better, and keep them from undergoing further destruction and deterioration.

Everyone, especially the consumer, knows the price of lumber is high and going higher. Those who own timber should take care of it, just as any other property. This does not mean they ought to let it stand and go to waste. Timber should be used, but used properly. It should be utilized in an economic way. Also a new growth should be secured and freed as far as possible from forest fires, especially dangerous to newly cut-over lands.

No remaining woodland should be cleared without carefully considering whether it is worth more for farm land than for timber. Certainly some should never be cleared, but kept for tree growth; for if cleared and put under cultivation, they would soon wash away, unprotected by the forest cover. Nearly everyone can bring to mind land of this character, which has been cultivated only a few years, and which has become worn out, full of gullies, and shows many "hang-rocks" on the surface. The washing away of the soil has left rock outcroppings, which would make the land difficult if not impossible to cultivate, even though it had not become poor.

It necessarily takes a great deal of timber to supply the stove and fireplace. But a big saving of the better class of timber could be made and still have them well furnished. Many trees of the better class find their way to the "wood-pile" because they are easier to "work up" than the knotty trees. The good trees should be allowed to grow and mature for a more profitable use. There is usually enough dead and down timber, and trees of poor quality and inferior species to supply fire-wood, and besides, the room they take up is frequently needed to give sufficient space for the more rapid growth of the better species. It may take more time to prepare the poorer than the better class of trees for wood, but a gain will be made in saving the latter for lumber.

The farmer would scarcely think of attempting to grow his cotton and corn crops without a certain amount of thinning. The same principle applies to trees. The scrubby and inferior ones can be cut over for use and the stand left improved. Even if thinning is not necessary to give room for growth, the space occupied by them, if they are removed, would have a chance to be taken up by the better class of trees left standing. A man can exercise as much judgment and show as much business ability in managing his timber as in any other phase of his work.

Fire damage to trees.—One of the chief ways of protecting woodlands is to keep fires out of them. Every other kind of property subject to fire damage has more fire protection than timber. When buildings catch on fire the alarm spreads rapidly and aid comes from all directions. In the country, town, or city the cry for help from fire has a ready response, and every effort is made to save life and property, since there exists a strong sentiment against loss by fire from buildings and their contents.

On the other hand, the boiling smoke of a forest fire rolls up from the woods, or mountain side; no alarm is given by shout nor bell; no crowd nor firemen rush to the scene. Men and women go on about their business. Some look at it indifferently, others gaze with admiration at the size and brilliancy of the flames, or the enormous clouds of smoke rolling heavily upward. They may not feel that damage is being done, because they do not realize the injury to forests from fire. They may not care, but yet they are gazing upon a source of destruction from which the people of the State suffer an immense loss every year. The injury is of such a nature that it does not come as close to us as that from loss of other property. For example, we live in our houses built especially for our com-

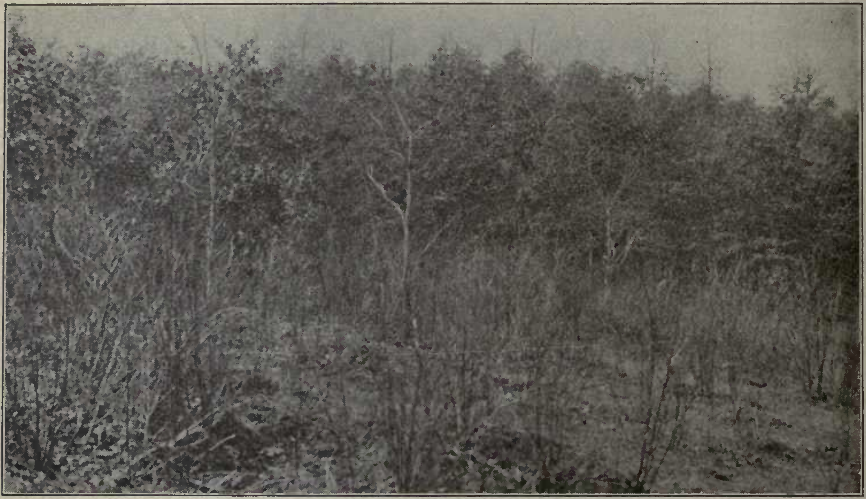


FIG. 1. Showing a stand of young oaks, 15-20 years old, near Tracy City, and the forest conditions where fires have not occurred for several years.

fort, and at an expense of money and hard work; our farm lands yield us provisions, and products for quick money, and any injury to these possessions affects us at once. But the benefits from our forests are not so direct, and therefore if they burn, the loss is not felt so quickly. A stand of young timber may burn over and no marked damage show at a glance; a majority of the trees may put out leaves the following spring, and the area appear full of life. The same woodland burns over every few years and still shows, especially at a distance, a good cover of leafy tree tops in the summer, yet this stand of young trees has suffered and will continue to suffer as long as fires run through them. Portions of bark on the butts have been scorched and have died; the dead places give rise to disease, rot and hollow butts which stay with the stand throughout its lifetime, and render a big per cent of the timber unfit for lumber. A great many trees break off at the ground because the stump was weakened first by fire and then was attacked by insects, fungi, or disease of some sort. Such is the case everywhere, and people have no doubt become so accustomed to it that they take it as a matter of course without stopping to lay the cause to forest fires that began when the trees were very small, and have recurred at irregular periods.

The saw-mill operator is well acquainted with these defects whether or not he thinks of the cause, and when he buys standing timber he is sure to make a certain per cent reduction in his estimate, because of them. The farmer often wonders why so many of his trees have hollow butts. One of the chief reasons is their having been burnt repeatedly from the time they were small. The burnt places on the stumps decayed, perhaps became infected with insects, and when the next fires came along the dead wood burned a little more, helping to kill the sap next to it, thus enlarging the size of the burn. It can be easily seen how this process, repeated time and again, results in a number of diseased and hollow butts by the time the area has on it a stand of large trees.

Our future timber supply must come from the sprouts and seedlings of our woodlands. They stand for the same thing among trees that babies and children do among men. A large amount of the timber that could be produced is lost on account of damage from fire. The very part of the tree that should give the clearest, strongest and best lumber has to be left in the woods. The total of such butt logs makes a large amount, and this loss places upon the people an extra tax in the form of a higher price of lumber, to say nothing of the inferior grades. No tree can grow its fastest if constantly burned and diseased; no land can produce its best if it constantly has the decayed vegetation removed. In order to keep our woodlands in condition for their best and most rapid production of timber, they must have protection from fire.

Fire damage to run-off.—Besides the loss in tree production, another phase of the serious damage resulting from forest fires is the rapid run-off of the rainfall and the hastened evaporation resulting from the constant burning of the leaf litter. A heavy downpour is followed by a rapid rise in the streams, often sufficient to carry them out of banks, and to sweep away fences, logs, crops, etc. This is looked upon as a natural event and unavoidable; water falls and it must have some way of escape. But it need not have a free and unobstructed right of way overland to wash and pillage. A part of the rainfall is taken up in wetting vegetation before it reaches the ground, a part evaporates, but as much of the remainder as possible should find a way underground, and so far as our forests are concerned this could be accomplished by a little precaution.

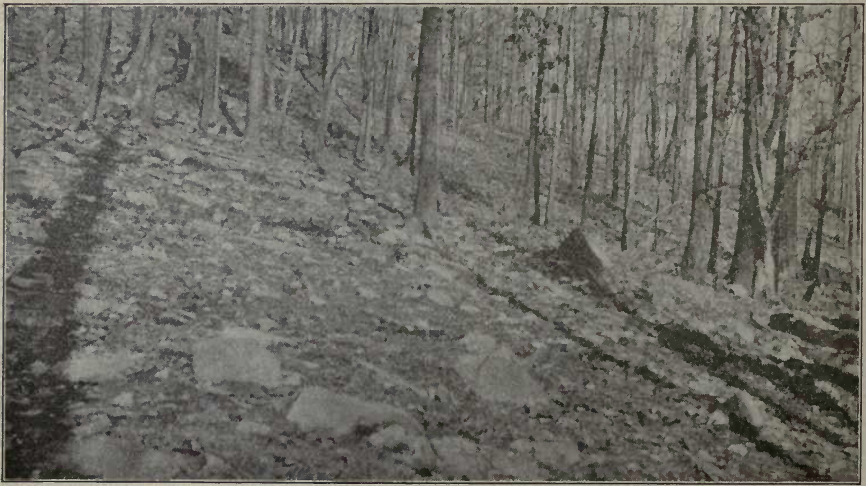


Fig. 2. A sample of the mountains near South Pittsburg, where forest fires have kept the ground cover burned off. Erosion and injury to trees are very noticeable in such areas.

The forests, by the annual shedding of their leaves, furnish a ground covering that absorbs and holds a large amount of water until it can soak into the earth. This litter is a natural ground protector and one that is provided by the trees throwing off what they no longer need. It should be kept and preserved; in other words, it should not be allowed to catch on fire.

In the mountains around Sewanee, Monteagle, Tracy City and South Pittsburg, I have recently seen streams swollen out of all proportion, because the repeated forest fires have prevented the accumulation of a thorough ground cover. There can be no question that the high waters of the streams of Tennessee, during the wet season of the year and the low water during the dry season, are partly due to the destruction by fire of the leaf litter on the forested lands.

Fire damage to birds and game.—There is a great deal said about the general scarcity of birds and game. Not only are certain kinds of song birds rare, but also game birds, such as quail, and turkey, becoming scarce. Deer are rare and apparently becoming fewer in numbers, and likewise other wild animals that in many parts of the State used to afford the hunter a certain amount of sport and profit. While this may be largely due to other causes, yet forest fires can certainly be held responsible for taking a part in it. There are certain restrictions by law that place a protective influence around game and birds. Some are protected all the time, others in certain seasons of the year, and during the open season the number lawful to bag in a day is limited. But forest fires are freely permitted to destroy and drive out all they can. They may happen any time of the year when the leaves become dry enough to burn. Certain song birds as well as game birds live in the woods, build their nests in the leaves, grass, shrubs and bushes, and rear their young there. If the woods burn before the nests are built, the ground litter is destroyed in many instances so that it does not furnish proper nesting places. The birds are thus forced to other quarters. The nests are exposed to fire danger from the time they are built until abandoned by the young birds. If the woods burn after the nests contain eggs or young birds, there is no question as to what becomes of them. This is true, both of song birds that nest on or near the ground, and of game birds, such as quail and turkey mentioned above.

Furthermore, forest fires destroy the feed for birds. The flames consume seed and other material that support bird life, and make living hard or impossible, for them. Their lodging places, and the small undergrowth that protects them, are injured, thus destroying the natural conditions under which they thrive.

The deer is a timid animal and wishes seclusion. When forest fires constantly sweep through the haunts of these animals, they are greatly disturbed and driven out for at least a time. It is said that hunters often start forest fires to rout the deer, and then shoot them when attempting to escape.

Although these birds and animals receive recognition for protection by law, from hunters, yet their breeding places and lives are constantly endangered and often destroyed through the ever recurring and little heeded forest fires.

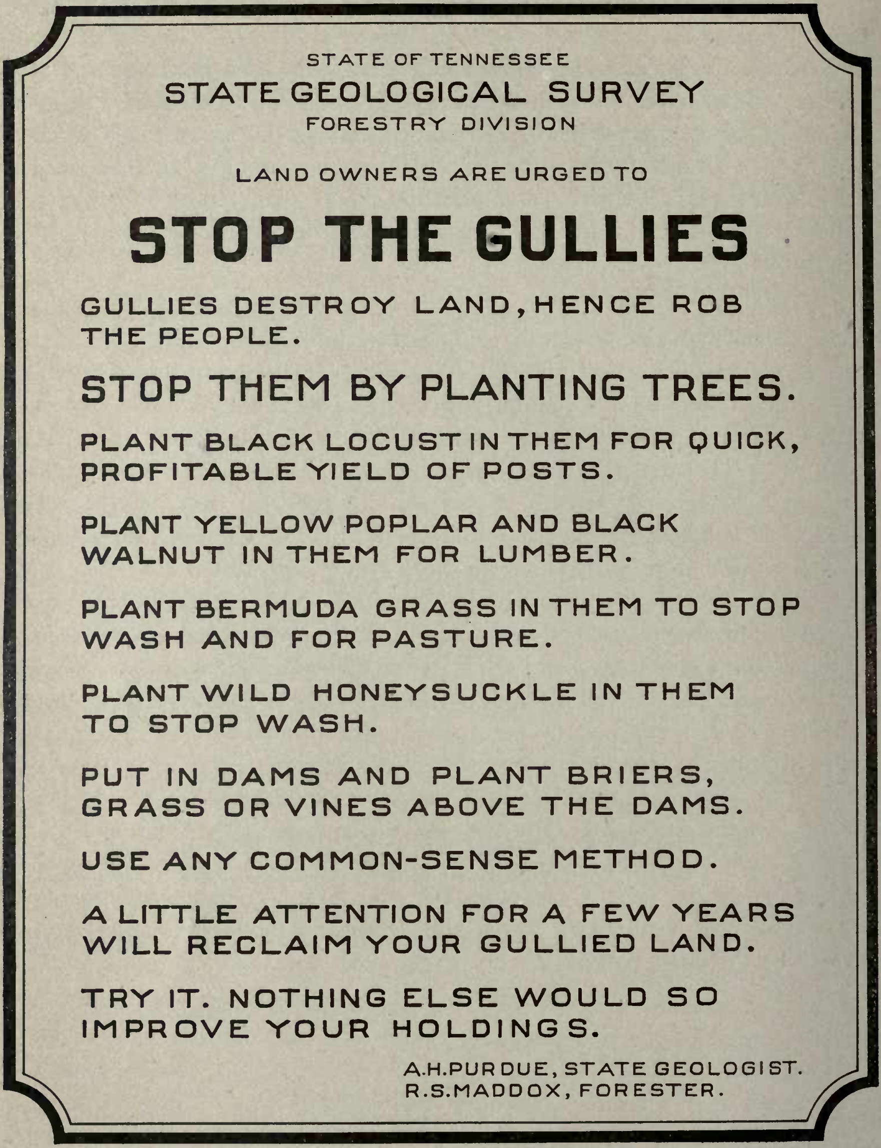
Fire damage to grazing.—For many years the mountains in the West have been used for stock ranges. Although the vegetation is comparatively scant, requiring many acres on the average for each animal, the area is so large that it has supported yearly hundreds of thousands of head. For a long time the stockmen made a practice of burning off the mountains with the idea of improving the grazing. But when those lands were set apart as national forest reserves, and put under the administration of the federal government, one part of the work was to put an end to forest fires. As is well known, it is often very difficult to get an old practice stopped, especially if the ones who practice it thoroughly believe in it. So when these grazing lands came under the management of the federal government, and permits were issued to the stockmen to graze their animals thereon, they still believed in the theory of burning as helpful to grazing. But through the government's patient and careful work of range protection from fires, the stockmen began to see that their grazing lands were better if fires were kept out; that fires were a detriment to the grass and forage. In other words, they were shown that they had been doing the wrong thing by allowing their grazing lands to be overrun by fire.

The mountain lands of Tennessee afford grazing to numerous herds of cattle every year. They form a sort of public range to stockmen who live close enough to use them for that purpose, and no doubt suffer from many forest fires, started in the belief that they are a benefit to the grazing. The chances are also that many fires are set because they keep down the underbrush so the stockmen can ride through more easily and find their stock with less difficulty. While the men may be temporarily aided personally by this burning, the damage to the woods is considerable. The grazing also is injured, and the fire has the same injurious effect upon the soil, water-flow and trees, as if it had been set for any other purpose. It is reasonable to believe that when grass and weeds are constantly burned off their growth is injured. Woodlands better serve the public with the fallen timber left for wood, and the leaf cover left to help hold rainfall, than when kept burned over; for repeated burning causes the ground to remain bare, increases floods, and also produces defective timber.

Grasses and forage plants can not have the greatest growth unless they have the best soil. Forest fires never help soil. They burn off the leaves and decayed vegetation, the very things that help hold moisture and add fertility to the land. They leave the ground exposed to erosion, and even the ashes that might otherwise have aided plant growth, are easily washed away; they frequently burn or scorch the soil, making it further impoverished for plant growth. Evaporation takes place more rapidly; the soil becomes hard and dry, and plant life can not thrive best under such conditions.

Fire damage to fish.—Everyone knows of the big volumes of water that pass out through our streams during winter and spring; and that streams get very low during the summer and fall. Great quantities of fish can not grow in streams, even those with large beds, if they contain but little water. No one would expect a river to be an excellent fish stream if it went dry or became very low during a part of every year. The smallest amount of water in a stream, at any time of the year may determine the amount of fish that stream can maintain. It may be claimed that a supply of fish will come up stream during high water, and this is no doubt true, but if the streams from which they may come have been likewise low, then their producing capacity has also been diminished and we are forced to admit our fish supply has been lessened all round. And too, if a large number were to come up stream and not go back with the retiring water, when the stream reaches its low mark, it would not be able to support an extra number. Thus some would necessarily die. Low water becomes impure and stagnant, and not best for fish production.

Our streams furnish energy for power plants and other industries, but often is deficient in low water. River freightage is diminished on account of the low water of the rivers in the dry season. And although other causes work to help bring about this lessened amount of water, forest fires must be charged with a very great deal of it.



STATE OF TENNESSEE
STATE GEOLOGICAL SURVEY
FORESTRY DIVISION

LAND OWNERS ARE URGED TO

STOP THE GULLIES

GULLIES DESTROY LAND, HENCE ROB THE PEOPLE.

STOP THEM BY PLANTING TREES.

PLANT BLACK LOCUST IN THEM FOR QUICK, PROFITABLE YIELD OF POSTS.

PLANT YELLOW POPLAR AND BLACK WALNUT IN THEM FOR LUMBER.

PLANT BERMUDA GRASS IN THEM TO STOP WASH AND FOR PASTURE.

PLANT WILD HONEYSUCKLE IN THEM TO STOP WASH.

PUT IN DAMS AND PLANT BRIERS, GRASS OR VINES ABOVE THE DAMS.

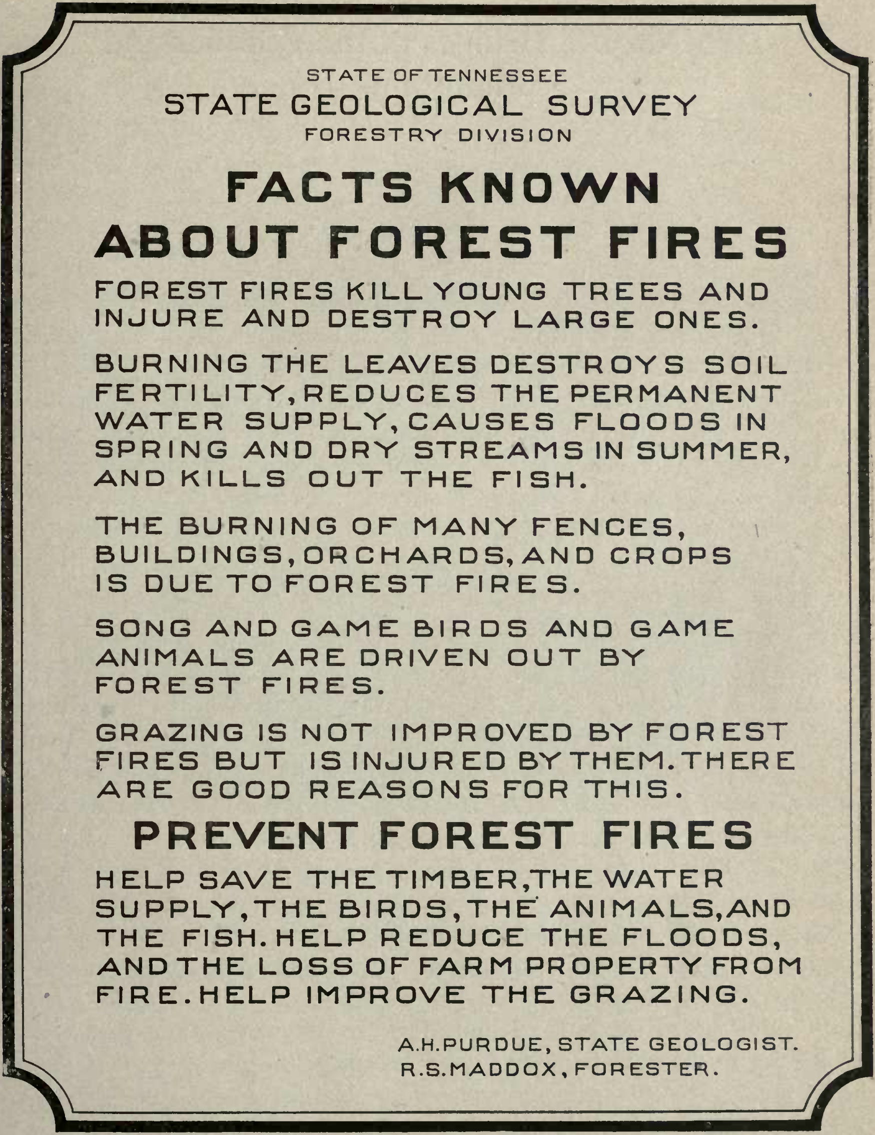
USE ANY COMMON-SENSE METHOD.

A LITTLE ATTENTION FOR A FEW YEARS WILL RECLAIM YOUR GULLIED LAND.

TRY IT. NOTHING ELSE WOULD SO IMPROVE YOUR HOLDINGS.

A.H.PURDUE, STATE GEOLOGIST.
R.S.MADDOX, FORESTER.

The above cut is made from a drawing for a poster that is being prepared by the State Geological Survey, to be put up in those parts of the State where waste from washing is greatest, and where a special effort is being made to have gullied lands reclaimed; but it is applicable wherever land washes. The size of the poster is 10 by 13 inches.



STATE OF TENNESSEE
STATE GEOLOGICAL SURVEY
FORESTRY DIVISION

FACTS KNOWN ABOUT FOREST FIRES

FOREST FIRES KILL YOUNG TREES AND INJURE AND DESTROY LARGE ONES.

BURNING THE LEAVES DESTROYS SOIL FERTILITY, REDUCES THE PERMANENT WATER SUPPLY, CAUSES FLOODS IN SPRING AND DRY STREAMS IN SUMMER, AND KILLS OUT THE FISH.

THE BURNING OF MANY FENCES, BUILDINGS, ORCHARDS, AND CROPS IS DUE TO FOREST FIRES.

SONG AND GAME BIRDS AND GAME ANIMALS ARE DRIVEN OUT BY FOREST FIRES.

GRAZING IS NOT IMPROVED BY FOREST FIRES BUT IS INJURED BY THEM. THERE ARE GOOD REASONS FOR THIS.

PREVENT FOREST FIRES

HELP SAVE THE TIMBER, THE WATER SUPPLY, THE BIRDS, THE ANIMALS, AND THE FISH. HELP REDUCE THE FLOODS, AND THE LOSS OF FARM PROPERTY FROM FIRE. HELP IMPROVE THE GRAZING.

A.H. PURDUE, STATE GEOLOGIST.
R.S. MADDOX, FORESTER.

The above cut is made from a drawing for a poster that is being prepared by the State Geological Survey, to be put up in those parts of the State where forest fires are most common; but it is applicable wherever there are forests. The size of the poster is 10 by 13 inches.

Two Natural Bridges of the Cumberland Mountains

By Wilbur A. Nelson.

There is probably no portion of Tennessee more beautiful or more interesting to the traveler than the Cumberland Mountains—a rugged belt which stretches nearly north and south across the State, forming a natural barrier between the middle and eastern portions of the State.

Among the many things of interest to the geologist and general observer are two natural bridges, which occur in this region. One, which has been known for years, is about three miles southwest of Sewanee in Franklin County, and is a point of interest to all visitors on the mountain. During the summer of 1913, the writer observed another, located two miles northwest of Dayton, on the eastern escarpment of Walden Ridge. It is so surrounded by trees that unless its location were known one would pass within a hundred yards of it and be ignorant of its existence.

Mode of formation.—The history of the two bridges is similar. The Cumberland Mountains are composed of horizontal beds of alternating sandstones and shales. The bridges occur in the thick sandstone, where the latter forms bluffs along the face of the mountain. A marked vertical jointing, parallel to the face of the escarpment, gives the abundant rainfall opportunity to disintegrate channels 50 to 100 feet back from the escarpment. These channels finally reach, at a lower level, a softer layer of sandstone which generally occurs near the base of the bluff. The water disintegrates the rock very easily and makes its way to the base of the bluff through a joint. This at first a small joint, gradually enlarges until a sufficient size has been reached, when the process is rapidly augmented by the thin bedded sandstone falling down of its own weight, thus completing the formation of the bridge. Eventually the processes that form the bridge destroy it by causing it to collapse and leave only a jagged gate, through which the water flows.

In addition to the water forming a channel along the joint plane of the sandstone, there occurs at each of the two bridges a small spring, which gushes out at the base of the solid sandstone wall, just back of the bridge arch. While the surface water, which flows down through the vertical joints is responsible for separating the arch from the sandstone that caps the mountain, the water from the spring is an important agency in undermining the separated part and forming the bridge arch.

Sewanee natural bridge.—The Sewanee natural bridge is located in Franklin County, three miles northwest of Sewanee, on the west side of Lost Cove. The capstone of the mountain at this point, the Sewanee conglomerate, is the rock in which the bridge occurs. Going down a slight declivity for a hundred yards, one suddenly comes to the upper bluff and sees lying at his feet this wonder of the Cumberland Mountains, while beyond stretches out the narrow, sinuous valley of Lost Cove, flanked by the densely wooded mountains in the distance. In the autumn, when the foliage takes on the colors of the rainbow, this picturesque spot supplies a scene of charming beauty.

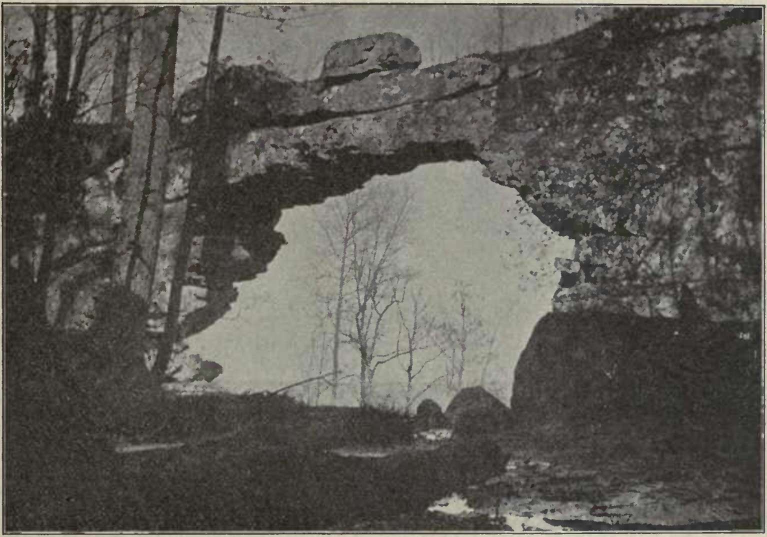


FIG. 1. Sewanee natural bridge. (Photo by Judd.)

The bridge is made of coarse, white, alternating hard and soft sandstone, containing a few small, white, quartz pebbles. The length of the inner span is 27 feet, its height 18 feet, while the thickness of the rock in the center is five feet. At this point it is made of two thin parallel bands of sandstone, the lower one three feet, and upper one two feet thick. The width of the arch at this point is seven feet. The length of the bridge from where it leaves the main bluff to where it joins again, is 130 feet. At the ends of the bridge the width has increased from 7 to 25 feet. The arch is separated from the main bluff by a distance of 25½ feet. In the base of the main bluff, a little to the south of the center of the arch, is a small grotto, 25 feet wide, six and a half feet high, and extending back under the bluff 15 feet. Three small springs flow from the back of this cavity and form a small stream, which flows out under the arch of the bridge.

To this spring is due the erosion of most of the bridge, although it was supplemented by the water running down through the joint plane, which at present forms the inner side of the bridge. At the same time the under side of the bridge was being broken down, and the arch growing larger.

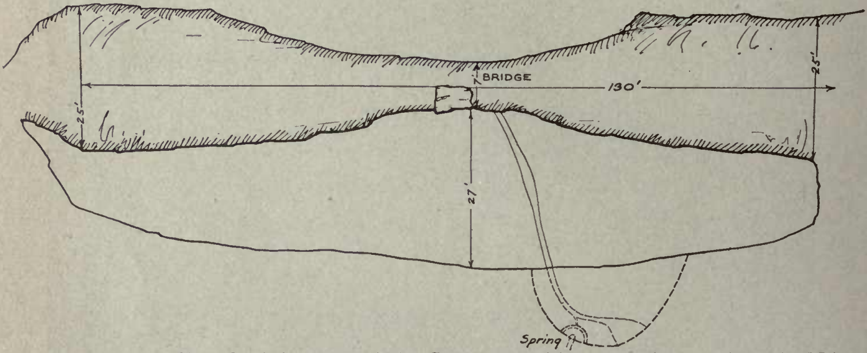


Fig. 2. Diagram of the Sewanee bridge, top view. (W. A. N.)

The rocks forming the top layer of the bridge were being eroded by natural processes, so that one can see from the picture that at least one layer 30 inches thick has been removed. This is evidenced by the small block-like remnant which remains.

Gooch Creek natural bridge.—This bridge, which is on the escarpment of the uppermost bluff, lies on the northwest side of Gooch Creek, three and a half miles north of Dayton, Tennessee. The property belongs to A. W. Walker of that town. The best way to reach it on foot is to follow the railroad to the coke ovens of the Dayton Coal & Iron Company, then turn east and take a logging road over an outlying ridge and down into Gooch Creek ravine, where there is a temporary saw-mill. From this point go about one-fourth of a mile up the creek and then climp up the escarpment of the mountain, 400 feet to the top of Walden Ridge, where the bridge is located. By road one can go up Stewart Gap to the top of the ridge, then walk south a half mile to the bridge.

This bridge is so surrounded by trees that it is impossible to get a good view of the arch, but the figures of its dimensions will give some idea of its size.

The greatest inside length of the span is 67½ feet, its height 33 feet, and the thickness of the arch in the center is 18 feet. The width of the arch at this point is 35 feet, while it is 135 feet from end to end. The bridge, which at both ends has a width of 50 feet, is separated from the main bluff by a distance of 19 feet. The Morgan Spring sandstone which composes the bridge is a coarse, yellowish, white sandstone, and does not weather easily. Occasionally one will find a few small, white, quartz pebbles. The rocks are mostly massive and thick bedded, and have a dip of about two degrees toward the mountain, which is to the northwest. The Morgan Springs sandstone is from 100 to 200 feet thick and forms a well defined escarpment along most of the eastern face of Walden Ridge.

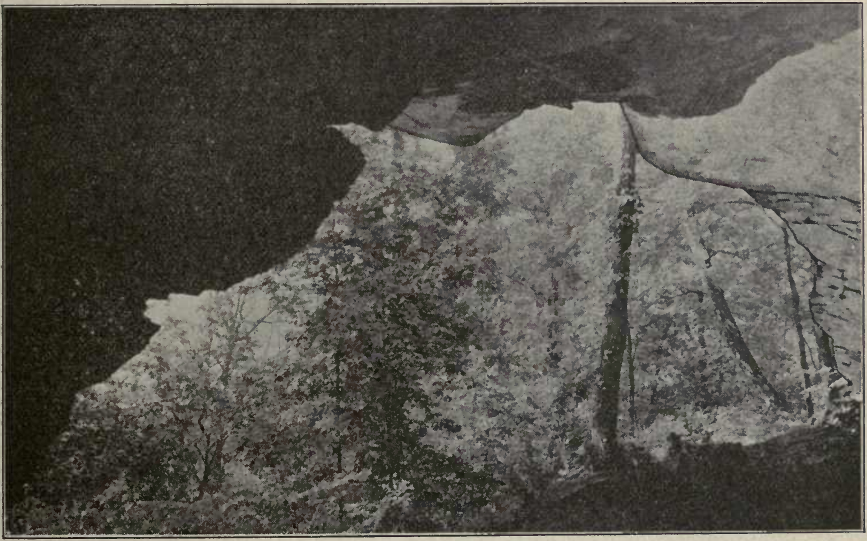


Fig. 3. Gooch Creek natural bridge. (W. A. N.)

In the face of the bluff back of the arch of the bridge is a small basin-like spring about four feet from the foot of the bluff, which forms a natural drinking basin. At the time the locality was visited, which was during a very dry period, the flow was so weak that the overflow was just sufficient to wet the surface of the bluff below the spring. Only during the wet seasons does any water flow through the arch, and this comes primarily from a small surface stream which flows into the north end of the rift behind the bridge, and then under the arch.

This bridge has been formed in identically the same manner as the Sewanee natural bridge, but is not so old. The spring coming from the face of the bluff at this bridge, is weak, while at the Sewanee bridge the spring is the main source of water supply. The undermining of the rock of the arch, which is still thick and massive, is only slight.

Doctor L. C. Glenn reports that another natural bridge exists near the eastern edge of the plateau, in the region just north of La Follette.

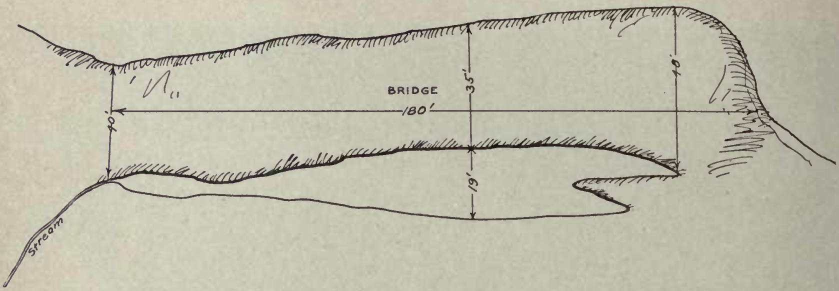


FIG. 4. Diagram of Gooch Creek natural bridge. Top view. (W. A. N.)

News Notes

A map of McNairy County is at present being made by the State Geological Survey. It will show all the roads, railroads, towns, residences, schoolhouses, churches, and streams. The scale of the map will be one mile to the inch. Mr. F. W. Farnsworth and Mr. C. R. Watkins, Jr., are employed in the field at this work. Mr. Farnsworth, a member of the United States Geological Survey, but temporarily secured for this work, has been engaged on many maps of this kind. His home is in Dayton, Tennessee. Mr. Watkins, of Nashville, is a civil engineer and has recently been employed in railroad work in Tennessee. He is a graduate of the Virginia Industrial Institute.

The object of such work is to prepare detailed maps of counties of the State which have not previously been surveyed, in order that the geological formations and soils may be represented upon them. Very little of such mapping has ever been done in Tennessee. McNairy County, since it contains material which represents most of the geological formations of West Tennessee, supplies the key to the geological problems of the whole region. It is the intention of this Survey to continue such detailed mapping of the counties of the State as fast as the means at its command will permit. Besides their use for geological and soil mapping, these maps will be of great service to the people of the State, and those outside the State, seeking information about it. Many requests have already been made by the farmers of McNairy County, for copies of the map, when it is published.

To accompany a report on the iron ores of Lewis County, which is now being prepared by Mr. Reese F. Rogers, formerly a member of the State Geological Survey, but now a member of the U. S. Bureau of Soils, a detailed map of that county is being drafted, and will be published soon. The map shows the location of the mines, prospects, and banks of the iron ore deposits. Mr. J. Trousdale Haden, who has recently come to the employ of the State Geological Survey, is doing the drafting of this map as well as that of the coal and marble reports, which are now in preparation by the geologists, Glenn, Nelson and Gordon.

Extensive coal sampling, under the direction of the State Geological Survey, in coöperation with the U. S. Geological Survey, is being done in the Cumberland Plateau coal field. This is in connection with the report on coal by L. C. Glenn and Wilbur A. Nelson. The sampling is being done by Mr. Frank R. Clark, Associate Geologist of the United States Geological Survey. Mr. Clark was selected for this work by the U. S. Geological Survey on account of his large experience in taking coal samples. It has been arranged for the analyses of the samples to be made at the laboratory of the U. S. Bureau of Mines at Pittsburgh, Pa. The purpose of this is to have the analyses standardized so that they will be accepted and understood in all parts of the world.

Mr. R. S. Maddox, Forester of the Survey, is rapidly winning the coöperation of the farmers in the work of saving the washed lands of West Tennessee, by methods which are productive to the farmers themselves. Besides, he is urging the avoidance of forest fires. This work is of widespread public benefit as well as the means of lessening local devastation. Attention is called to the cuts of two posters appearing elsewhere in this issue. One relates to the reclamation of gullied lands, and the other to the prevention of forest fires.

Publications of Geological Survey of Tennessee Issued.

The following publications have been issued by the present Survey, and will be sent on request *when accompanied by the necessary postage.* Gaps in the series of numbers are of reports still in preparation:

Bulletin No. 1—Geological Work in Tennessee.

A. The establishment, purpose, object and methods of the State Geological Survey; by Geo. H. Ashley, 33 pages, issued July, 1910, postage, 2 cents.

B. Bibliography of Tennessee Geology and Related Subjects; by Elizabeth Cockrill, 119 pages; postage, 3 cents.

Bulletin No. 2—Preliminary Papers on the Mineral Resources of Tennessee, by Geo. H. Ashley and others.

A. Outline Introduction to the Mineral Resources of Tennessee, by Geo. H. Ashley, issued September 10, 1910; 65 pages; postage, 2 cents.

D. The Marbles of East Tennessee, by C. H. Gordon; issued May, 1911; 33 pages; postage, 2 cents.

E. Oil Development in Tennessee, by M. J. Munn; issued January, 1911; 46 pages; postage, 2 cents.

G. The Zinc Deposits of Tennessee, by S. W. Osgood; issued October, 1910; 16 pages; postage, 1 cent.

Bulletin No. 3—Drainage Reclamation in Tennessee; 74 pages; issued July, 1910; postage, 3 cents.

A. Drainage Problems in Tennessee, by Geo. H. Ashley; pages 1-15; postage, 1 cent.

B. Drainage of Rivers in Gibson County, Tennessee, by A. E. Morgan and S. H. McCrory; pages 17-43; postage, 1 cent.

C. The Drainage Law of Tennessee; pages 45-74; postage, 1 cent.

Bulletin No. 4—Administrative Report of the State Geologist, 1910; issued March, 1911; postage, 2 cents.

Bulletin No. 5—Clays of West Tennessee, by Wilbur A. Nelson; issued April, 1911; postage, 4 cents.

Bulletin No. 9—Economic Geology of the Dayton-Pikeville Region, by W. C. Phalen, for sale only, price 15 cents.

Bulletin No. 10—Studies of the Forests of Tennessee.

- A. An Investigation of the Forest Conditions in Tennessee, by R. Clifford Hall; issued April, 1911; 56 pages; postage 3 cents.
- B. Chestnut in Tennessee, by W. W. Ashe, issued December, 1911; postage, 2 cents.
- C. Yellow Poplar in Tennessee, by W. W. Ashe, issued January, 1914; 55 pages; postage, 3 cents.

Bulletin No. 13—A Brief Summary of the Resources of Tennessee, by Geo. H. Ashley; issued May, 1911; 40 pages; postage, 2 cents.

Bulletin No. 14—The Zinc Deposits of Northeastern Tennessee, by A. H. Purdue; issued September, 1912; 69 pages; 30 illustrations, postage, 3 cents a number.

Bulletin No. 15—Administrative Report of State Geologist, 1912.

Bulletin No. 16—The Red Iron Ores of East Tennessee, by E. F. Burchard; issued November, 1913; 172 pages; postage, 8 cents.

Bulletin No. 17—The Water Powers of Tennessee, by J. A. Switzer; issued April, 1914; 137 pages; postage, 8 cents.

Bulletin No. 18—Administrative Report of the State Geologist, 1914.

"THE RESOURCES OF TENNESSEE."—This is a quarterly magazine, devoted to the description, conservation and development of the State's resources. Postage, 2c a number. The following are the volumes and numbers issued, with the titles of the principal papers in each number:

Vol. I. No. 1—The utilization of the small water powers in Tennessee, by J. A. Switzer and Geo. H. Ashley.

No. 2.—The Camden chert—an ideal road material, by Geo. H. Ashley.
The Fernvale iron ore deposit of Davidson County, by Wilbur A. Nelson.
Cement materials in Tennessee, by C. H. Gordon.

No. 3—The gold field of Coker Creek, by Geo. H. Ashley.

No. 4—Coal resources of Dayton-Pikeville area, by W. C. Phalen.

No. 5—Economic aspects of the smoke nuisance, by J. A. Switzer.
Watauga Power Company's hydro-electric development, by Francis R. Weller.
The coal fields of Tennessee, by Geo. H. Ashley.

No. 6—Bauxite Mining in Tennessee, by Geo. H. Ashley.
A New Manganese Deposit in Tennessee, by Wilbur A. Nelson.
Road Improvement in Tennessee, by Geo. H. Ashley.

Vol. II. No. 1—The Utilization of the Navigable Rivers of Tennessee, by Geo. H. Ashley.
Dust Explosions in Mines, by Geo. H. Ashley.
The Rejuvenation of Wornout Soil Without Artificial Fertilizers, by Geo. H. Ashley.
Tennessee to Have Another Great Water Power, by George Byrne.
Manufacture of Sulphuric Acid in Tennessee in 1911, by Wilbur A. Nelson.

No. 2—The Ocoee River Power Development, by J. A. Switzer.
Exploration for Natural Gas and Oil at Memphis, Tenn., by M. J. Munn.

No. 3—The Power Development at Hale's Bar, by J. A. Switzer.
Notes on Lead in Tennessee, by Wilbur A. Nelson.

No. 4—The Tennessee Academy of Science.
The Preliminary Consideration of Water Power Projects, by J. A. Switzer.
Lignite and Lignitic Clay in West Tennessee, by Wilbur A. Nelson.

No. 5—The Growth of Our Knowledge of Tennessee Geology, L. C. Glenn.

No. 6—On the Impounding of Waters to Prevent Floods, by A. H. Purdue.
Drainage Problems of Wolf, Hatchie, and South Fork of Forked Deer Rivers, in West Tennessee, by L. L. Hidinger and Arthur E. Morgan.
The Waste From Hillside Wash, by A. H. Purdue.

No. 7—Where May Oil and Gas Be Found in Tennessee? By Geo. H. Ashley.
Spring Creek Oil Field, by M. J. Munn.

No. 8—The Monteagle Wonder Cave, by Wilbur A. Nelson.
Cave Marble (Cave Onyx) in Tennessee, by C. H. Gordon.

No. 9—The Valley and Mountain Iron Ores of East Tennessee, by Royal P. Jarvis.

No. 10—The Iron Industry of Lawrence and Wayne Counties, by A. H. Purdue.
Some Building Sands of Tennessee, by Wilbur A. Nelson.

No. 11—Tests on the Clays of Henry County, by F. A. Kirkpatrick. Introduction, by Wilbur A. Nelson.
Barite Deposits in the Sweetwater District, by Herbert B. Henegar.

No. 12—The Soils and Agricultural Resources of Robertson County, by Reese F. Rogers.
The Iron Ore Deposits in the Tuckahoe District, by C. H. Gordon and R. P. Jarvis.

Vol. III. No. 1—The General Features of the Tennessee Coal Field North of the Tennessee Central Railroad, by L. C. Glenn.
The Tennessee Coal Field South of the Tennessee Central Railroad, by Wilbur A. Nelson.

Vol. III. No. 2—State Supervision of Forestry, by L .C. Glenn.
Conservation of the Water Powers of Tennessee, by J. A. Switzer.
Water Supplies for Cities and Towns, by A. H. Purdue,
Types of Iron Ore Deposits in Tennessee, by C. H. Gordon.
The Causes and Nuisance of Smoke, by Wilbur A. Nelson.
Geology and Engineering, by A. H. Purdue.

Vol. III. No. 3—The Gullied Lands of West Tennessee, by A. H. Purdue.
White Rock Phosphate of Decatur County, Tennessee, by T. Poole Maynard.
Mineral Products Along the Tennessee Central Railroad, by Wilbur A. Nelson.
Relations of Water Supply to Health, by J. A. Switzer.

Vol. III. No. 4—Minerals of Tennessee, Their Nature, Uses, Occurrence and Literature, by A. H. Purdue.
Building Precautions Against Earthquake Disasters, by Olaf P. Jenkins.

Vol. IV. No. 1—Relation of Water Supply to Health, by J. A. Switzer.
Earthquakes in East Tennessee, by C. H. Gordon.
The State Geologist and Conservation, by A. H. Purdue.
A. Tripoli Deposit near Butler, Tenn., by L. C. Glenn.

No. 2—The Brown and Blue Phosphate Deposits of South-Central Tennessee, by J. S. Hook.
Discussion, Lucius P. Brown.
Bauxite in Tennessee, by A. H. Purdue.

No. 3—Economic Geology of the Waynesboro Quadrangle, by N. F. Drake.
Recent Water Power Development in Tennessee, by J. A. Switzer.
Two Natural Bridges in Tennessee, by Hugh D. Miser.
Road Materials of Tennessee, by A. H. Purdue.
Report on the Water Powers of Tennessee.

No. 4—The Need of a Soil Survey of Tennessee, by C. A. Mooers.
The Geology of Perry County and Vicinity, by Bruce Wade.
Indexes to Volumes III and IV.

Vol. V. No. 1—The Hydro-Electric System of Tennessee, by J. A. Switzer.
West Tennessee Gullied Lands and Their Reclamation, by R. S. Maddox.
The White Phosphates of Tennessee, by J. S. Hook.

Volume V　Number 4

5

OCTOBER, 1915

THE RESOURCES OF TENNESSEE

Published by the State Geological Survey

NASHVILLE, TENNESSEE

PROPERTY OF DIVISION OF
FORESTRY
COLLEGE OF AGRICULTURE
UNIVERSITY OF CALIFORNIA

STATE GEOLOGICAL COMMISSION

GOV. TOM C. RYE, *Chairman*

DR. BROWN AYRES, *Secretary*
President, University of Tennessee

H. KNOX BRYSON
Commissioner of Agriculture

DR. J. H. KIRKLAND
Chancellor, Vanderbilt University

BISHOP A. W. KNIGHT
Vice-Chancellor, University of the South

R. A. SHIFLETT
Chief Mine Inspector

GEOLOGICAL CORPS

A. H. PURDUE
State Geologist

OLAF P. JENKINS
Assistant Geologist

PAUL C. BOWERS
Chemist

J. A. SWITZER
Hydraulic Engineer

R. S. MADDOX
Forester

CONTENTS

The Soils of Tennessee..C. A. Mooers
Recent Oil Development near Oneida, Scott County, Tennessee.........L. C. Glenn
Publications of the Geological Survey of Tennessee:

Typical view of upland plateau of West Tennessee.

PROPERTY OF DIVISION
FORESTR
COLLEGE OF AGRICULT
UNIVERSITY OF CALIFORNI

The Soils of Tennessee*

By C. A. Mooers.

INTRODUCTION.

Tennessee upland soils are of residual origin. That is, they were formed where they lie, or nearly so, by the weathering of rock, or of other geological material, similar to that which now underlies them. Each kind of rock or other material gives rise to a definite kind of soil as is evidenced by a certain uniformity of color, texture and plant food supplies. The line of demarkation between these different soils is often surprisingly easy to distinguish. For example, in a valley where the two soils meet, it is frequently possible to stand with one foot on the heavy yellowish-gray soil derived from the Chickamauga limestone and the other on the brown-colored loam, whose origin is the Holston marble. Where the marble outcrops above the blue limestone, the brown loam may be carried down and over the blue limestone and often at such a depth that the latter has no appreciable effect on the surface soil.

The fact that each geological formation produces a characteristic soil accounts for the remarkable difference in both the fertility and crop adaptability of the various areas throughout the State. Poor land may lie in juxtaposition to that whose agricultural value is several times as great, not because of differences in cropping and manuring, but because of some fundamental differences in the rock from which each was derived.

In this article the geological basis of classification will therefore be followed for the upland soils. The alluvial soils cover a relatively small area and vary greatly in character, which is governed in a large part by the velocity of the stream current at the time of the deposition, but also by the origin of the water-borne material.

---

*Requests often come to the State Geological Survey for information concerning the soils of Tennessee. The large number of surface divisions of the State and of geological formations that have produced its great variety of soils, have made it difficult satisfactorily to comply with these requests. For this reason Professor Mooers, who is the best authority we have on the soils of Tennessee, was requested to prepare this paper. If the reader can have before him, the geological map of the State, published by this Survey, his interest and understanding of the paper will be much greater than it can be without the map.—A. H. P.

In a general way there is considerable similarity in the texture of the upland soils. Throughout the State the prevailing types are silt loams and loams, and there is one large area, the Cumberland Plateau, covered with fine sandy loams. True clay soils are rare, and true sandy soils are almost unknown except along the river banks. The subsoils are heavier than the surface ones and include heavy silt loams, clay loams and clays.

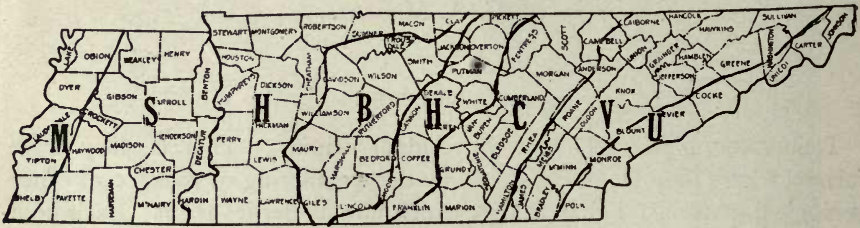


FIG. 1. Map showing the physiographic divisions of Tennessee.
U. Unaka Chain, or Smoky Mountains.
V. Valley of East Tennessee.
C. Cumberland Plateau.
HH. Highland Rim.
B. Central Basin.
S. Slope of West Tennessee.
M. Mississippi Bottoms.

For convenience in reference, as well as for other reasons, each of the natural divisions of the State is considered separately. They differ appreciably in both elevation and topography. East Tennessee is the most elevated and contains the Smoky Mountains on its eastern border and the parallel ridges and valleys which make up the broad depression of the Great Valley of East Tennessee, lying between the Smoky Mountains and the Cumberland Plateau. Middle Tennessee has been likened to a dinner plate, the Central Basin corresponding to the bottom of the plate; and the Highland Rim to the rim of the plate. The hills of the Basin are inclined to be either isolated or in groups rather than forming parts of ridges.

The Cumberland Plateau, which forms a part of both East and Middle Tennessee, must, however, be considered separately, as it is distinctly different in both soil and climate from any other large area in the State.

West Tennessee has the lowest elevation of the three divisions of the State, and may be described as an undulating slope, extending from the Highland Rim on the east to the Mississippi River on the west.

THE SMOKY MOUNTAINS.

The Smoky Mountain section is a narrow belt from two to twenty miles wide along the eastern border of the State, and has an area of about 2000 square miles. The altitude varies from 2000 to 6000 feet, with occasional depressions as low as 1000 feet. This is the roughest and most mountainous part of the State, and for the most part is not at all suitable to cultivation.

The soils are apt to be shallow and rocky, even on the tops of the mountains, which have been used for many years for summer grazing grounds for cattle, and to a lesser extent for other stock. The mountain sides are very steep with usually very narrow valleys, but occasionally a wide valley or "cove" is found where the soils and the farming conditions are practically the same as in the Great Valley. Also along the foothills are some farms and orchard sites. This section has furnished much timber and is now being purchased to considerable extent by the Federal Government for forest reserves.

THE GREAT VALLEY OF EAST TENNESSEE.

The Great Valley of East Tennessee comprises the section lying between the Smoky Mountains on the east and the Cumberland Plateau on the west, and covers about 9200 square miles. It is drained by the Tennessee River and its tributaries, and is an especially well-watered section of the State. The most prominent types of soil will be discussed under the headings which follow and which are indicative of the soil origin.

Marble and other high grade limestone soils.—The decomposition of marble and other high grade limestones has given rise to the most fertile and durable lands found in East Tennessee. These soils are distinguished by their color, which varies from a rather dark brown to red. They are brown-colored when newly cleared and where fertility has been maintained by good methods of farming. Where cropped for many years in corn, wheat, etc., with little regard to the maintenance of fertility, the brown color changes gradually to red, and the more the soil has been eroded and worn the lighter is the color.

These soils are for the most part loams, with rather heavy clay loam subsoils, and are naturally well suited to all of the common farm crops, such as corn, wheat, clover and grass, and forage crops in general. Also they are well, but not richly, supplied with all of the elements of plant food. Under live stock farming supplemented by good methods of soil management and cropping, fertilizers are not necessary, and even liming may not be profitable. They are not, however, rich in lime, a few tenths of a per cent. being all that is found by the chemical analyses that have been made. Where crops have been removed for years with little return of fertility, which is unfortunately the custom, liming is apt to be profitable, and may even be a necessity in order to grow red clover; for growing alfalfa, liming is even more necessary. Also phosphatic fertilizers may be found profitable under these conditions.

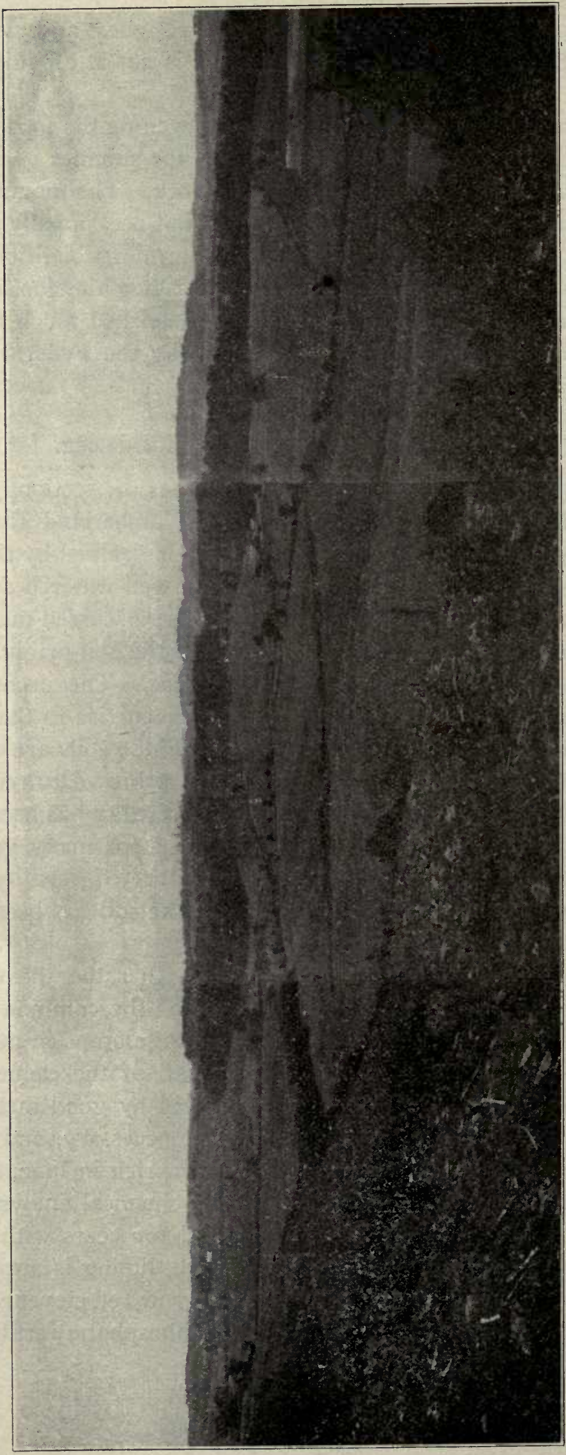


FIG. 2. East Tennessee landscape.

But even when run down, these soils respond readily to proper treatment and can be restored to high productiveness. Alfalfa is more easily obtained on them than on any other type of upland in this part of the State at present known to the Agricultural Experiment Station of the University of Tennessee, and farmers are finding this crop very profitable. As they are superior soils, it is not surprising to find them relatively high priced, forty to one hundred dollars an acre being not unusual. The chief drawbacks to these soils are the ease with which they are eroded when in cultivated crops, and the fact that outcrops of limestone rock prevent some parts from being cultivated. Bluegrass thrives, however, in such places and makes excellent pasture.

The soils described are found both on hillsides and in valleys wherever the marble formation occurs. They cover only a relatively small area, being found in narrow belts throughout the valley section.

Dolomitic soils.—The underlying rock over approximately one-half of the Great Valley is dolomite or magnesian limestone. This formation has given rise to soils which vary in both color and fertility, but which have certain characteristics in common. They may be roughly placed in two groups, the ridge or high hill lands, and the undulating lower lands. The former are lighter in color, contain much more coarse, angular gravel or chert, and are poorer than the latter. In fact, the dolomite ridges of East Tennessee are among the poorest soils of the State, being naturally very deficient in phosphoric acid and lime, and not well supplied with either potash or nitrogen. They are gravelly loams which are generally gray colored, but some are red colored and all have red colored subsoils. These soils are deep, well drained, stand drought as well as any, and respond readily to both manure and fertilizers.

The high elevations of the ridges, together with the nature of the soils, makes them well adapted to peaches, cherries and early apples. Grapes and small fruits thrive, and in some places strawberry growing in particular, has reached considerable commercial importance. These ridge lands are little used for general farm crops, and as a rule are covered with timber. Land values are low, ten to twenty dollars per acre being common prices.

The lower lands contain less chert and are apt to be redder colored than the ridge lands. The surface is rolling but is not unsuited to cultivated crops. These soils are nearly always somewhat deficient in both lime and phosphate and are apt to be poor in nitrogen and humus. They are best adapted to corn, wheat and forage crops, and when limed and fertilized will produce good crops of clover and grass. At the University Farm at Knoxville, alfalfa is successfully grown on this type of land, but not without special preparation.

In some instances the valley lands of dolomitic origin, especially where the dolomite is interstratified with non-magnesian limestone, are brown to dark-red in color, and are of extra fertility, ranking with the best limestone soils in this part of the State. Areas of this kind are found, for example, in the vicinity of Morristown and New Market.

Chickamauga limestone soil.—The Chickamauga or blue, "rotten", limestone is found throughout the East Tennessee Valley in narrow strips, which are often only one-eighth of a mile in width, but which may be fifty or more miles in length, running in a generally north-easterly and southwesterly direction. Upon disintegration, this rock produces heavy silt loams and clays, which may be dark colored when first cleared but under cultivation become gray and reddish yellow, the latter being the characteristic color of the subsoil. As this formation weathers easily, the soils are found in valleys and on low hills. Outcrops of the rock are not infrequent, and often are marked by cedar groves. Where of good depth, the soil is adapted to corn, wheat, forage crops and grass. Soil analyses and the results of field experiments show that this type is generally poor in phosphoric acid and lime, but rich in potash. The long cultivated lands are generally poor in nitrogen.

Fall plowing is especially advisable on this type of soil, in order to get a mellow seed bed for any summer crop. Liming is generally a necessity for a satisfactory growth of clover, and the use of phosphate should not be omitted.

Tellico sandstone soil.—The Tellico sandstone formation is found in narrow belts, generally occupying, on account of the hardness of the rock, the tops of the highest hills and ridges. The soils derived from it cover the tops and sides of the hills and may extend down to the valleys. They vary from brown to red in color and in general appearance might easily be confused with the marble soils previously described. Both kinds are often called "mulatto" soils. The Tellico sandstone soils are, however, much lighter than the marble soils, being classified as fine sandy loams. Both on account of their elevation and their texture, they are especially well suited to market garden crops, orchards and small fruits. When first cleared, they are well supplied with all of the elements of plant food, but the long cultivated soils need fertilizers and lime. With attention to these needs, alfalfa as well as clover may be grown successfully. Owing to the steepness of the hillsides which characterize this formation, erosion is liable to do great damage. This should be prevented by putting them in permanent pasture before the soil fertility is greatly reduced. Failure to do this has in many instances resulted in irreparable ruin.

These soils are by far the easiest tilled of any uplands in this part of the State. Winter cover crops, such as crimson clover, vetch and even rye, should be considered very important and may be turned under to advantage in the spring in preparation for a summer crop. Unfortunately the area covered by this type of soil is small and much of that is too steep for continued cultivation.

Soils of shale origin.—Shale or slate is found to a greater or less extent in various formations, such as the Tellico sandstone and Chickamauga limestone; and it makes up the body of other formations in which marble or limestone sometimes appears instead of shale, as is frequently true of the Sevier shale. The shales vary considerably in both chemical composition and color, which varies from red and yellow to black. Yellow and reddish colored shales are very common, and produce gray and yellowish colored soils with reddish yellow subsoils. They are often shallow and lacking in fertility. In fact, most soils of this kind are rated as the least desirable of all. They occupy lowlands in large part, but outcrops appear at all elevations.

Where these soils are of good depth, and especially where some limestone was mixed with the shale, they are fairly well suited to corn, wheat and grass, redtop in particular. Gray colored silty soils, often spoken of as "crawfishy", result from the decomposition of shale, and are especially poor and difficult to handle profitably.

Both chemical analyses and field experiments indicate that phosphate and lime are the chief mineral elements needed. Soils derived from the black shale, however, are often well supplied with lime and produce excellent crops of clover. Poverty in nitrogen is the rule. This may be remedied in part at least by the sowing of Japanese clover, to which they seem to be well suited, and by using the land for pasture purposes.

Overflow and bench lands.—Wide expanses of alluvial soils are of rare occurrence in Tennessee, but along the rivers and streams are found narrow belts of such soils, which are of considerable importance in the aggregate. The first bottom is the name often used for the portion which is overflowed annually. As a rule this is a sandy soil of high productiveness and is used almost exclusively for corn. The second bottom, or bench, which is seldom overflowed, contains more clay and other fine particles. Much of this is a fine sandy loam, but where deposition occurred in relatively still water, a heavy soil results.

The bench lands are generally very productive, and although corn is the common crop, they are well suited to clover and grass as well as to other forage crops. Much of them is too rich for wheat. These are naturally very valuable lands, but as they do not receive enough deposits from overflows to maintain their fertility, they have been reduced greatly in productiveness and are apt to be in need of manuring. Systematic crop rotations, which include clovers and other legumes, should be practiced on them. At the University farm these soils have not been found responsive to phosphating, except for alfalfa, but to be somewhat in need of lime for both clover and alfalfa.

Lying above the second bench may be found a third bench which is never overflowed now, but which in times past received river deposits, and was in fact formed in large part in this way. With this ancient river deposit, material from the neighboring uplands has been washed in and the soils are therefore of mixed origin. They are often more productive than the adjacent uplands, but vary with them in general character.

THE CUMBERLAND PLATEAU.

The Cumberland Plateau is an elevated tableland from 30 to 50 miles wide, extending across the State from Kentucky to Alabama. The area is about 5000 square miles. The average elevation is not far from 1800 feet, or nearly 1000 feet above the Great Valley of East Tennessee, or the Highland Rim of Middle Tennessee. The plateau is practically undeveloped from an agricultural point of view but offers many inducements to settlers.

The major part of this section is gently undulating, but there are areas so hilly and rough as to be unsuited to cultivated crops. The area of uncultivable land is further increased by the outcropping of the sandstone rock, which is near the surface over much of the area. The soils at best are shallow, two to five feet being common distances to the underlying rock of the cultivated fields. However, the rainfall is generally ample, being well distributed, and amounting to about 55 inches per annum, so that crops appear to suffer less here from dry weather than on the deep limestone soils of other sections. The prevailing soils are fine sandy loams which have good retentive subsoils. They are easily tilled, and on account of their excellent texture are suited to trucking crops, orchards and small fruits.

The prime cause of the lack of agricultural development is that the soils are naturally very deficient in both phosphoric acid and lime. This conclusion was reached from the results of chemical analyses of the soils and from field experiments which have been conducted by the Agricultural Experiment Station for the past eight years. Fortunately both of these elements can be supplied from deposits within the State at an expense which is not at all prohibitive of profitable results. At Crab Orchard on the line of the Tennessee Central Railroad, a thick bed of high grade limestone outcrops on the plateau and insures an inexhaustible supply of cheap limestone to that vicinity. Cumberland County has recently installed a crushing plant there and sells the rock at cost.

The supply of potash is indicated as poor by the chemical analyses, but the results of field experiments have seldom shown profitable returns from potash salts, even on long cultivated soils. However, under more intensive crop production than is now the rule, some potash is apt to be needed and is generally advisable for potatoes and trucking crops. The nitrogen and humus supplies of the new lands are fairly good, but very poor for the long cultivated ones. Attention must therefore be given to the maintenance of these supplies, which should not prove difficult with the information now available on this subject.

At the present time corn, forage crops, potatoes, apples, etc., are being grown to a limited extent. The chief dependence outside of the timber for an income, is the great free range where cattle and other live stock are fattened with the minimum of expense to the owners. Only a small portion of the land is cleared, though much of the best timber has been removed, and by burning over the land each year the growth of wild grass has been encouraged, though at the expense of the soil supply of vegetable matter.

The Agricultural Experiment Station has published a practical guide on the upbuilding of these soils for which lime and phosphate must be considered of fundamental importance.

THE CENTRAL BASIN OF MIDDLE TENNESSEE.

The Central Basin of Middle Tennessee has an area of approximately 5400 square miles. It is an undulating plain, 50 to 60 miles wide and 100 miles long, and has a general elevation of about 600 feet above sea level, but hills rising to 200 or more feet above the surrounding country are not uncommon. The soils are practically all of limestone origin, and are decidedly the most durable and productive under cultivation of any large area in the State.

The typical soil is a deep, brown loam which is easily tilled and is well adapted to a great range of farm and garden crops. In its virgin condition this type of soil was rich in all of the important elements of soil fertility, but continuous cropping in corn and wheat has greatly depleted the store of nitrogen. Also they are now in large part in need of liming to get satisfactory crops of clover. To restore these lands to their former productiveness the growing of legumes, clovers in particular, is a prime essential. With the aid of lime this can easily be done. The continuation of the present system of cropping will result in the further depletion of these naturally very fine soils. The loss of soils by erosion is also a serious matter and calls for the growing of much more grass than is the present custom.

According to the results of numerous field experiments, the adding of neither potash nor phosphate is apt to be profitable on the typical brown loam, so far as general farm crops are concerned. Chemical analyses show this type of soil to be especially well supplied with phosphate. Instances have been found, however, where acid phosphate has proved profitable, especially for some quick growing crop like Irish potatoes or alfalfa.

Red-colored loam.—In the vicinity of Murfreesboro are red-colored soils which differ somewhat from the typical brown loams of the Central Basin. In particular they are not so well supplied with phosphate, so that they respond readily to applications of acid phosphate. This type of soil has been planted extensively in cotton, as well as in corn and wheat, until its productiveness has been greatly reduced. Here again, greatly increased attention should be given to the growing of clover, alfalfa and grass, which can be materially assisted by liming and phosphating.

FIG. 3. Typical scene in the bluegrass section of Middle Tennessee.

Phosphatic soils.—Phosphate rock is found at different points in the basin and has given rise to some very rich, brown-colored, loamy soils which have an extra high content of phosphoric acid.

Under the usual system of cropping, these soils are apt to become poor in nitrogen and in some instances are greatly impoverished. For such a condition phosphate fertilizers are not only inefficient but are entirely unwarranted. Nitrogenous fertilizers, such as nitrate of soda, dried blood and cotton-seed meal, may be used to a limited extent, but the production of clover and alfalfa, the pasturing of land, and the careful saving and use of barnyard manure, are the important means of their permanent improvement.

Gravelly hill lands.—The gravelly hill lands of this section are known for their productiveness, and in this respect are the opposite of the gravelly hills either of East Tennessee or the "barrens" of the Highland Rim. The soils are loamy and of excellent texture. The great drawback to much of this area is the steepness and height of hills, which make manuring almost impossible, and limit the use of implements and farm machinery. These lands make very fine bluegrass pastures, and clovers generally thrive. By utilizing them for these purposes, the fertility is easily maintained. Neither fertilizers nor lime is apt to be required, but the need of the latter is sometimes indicated for old and depleted soils of this character.

Glady lands.—In the aggregate, a considerable area of the basin is not suited to cultivated crops, on account of either the outcropping of the limestone or of the shallowness of the soil overlying the rock. Such areas are naturally covered with cedars and are known locally as cedar glades. "Glady" land is therefore land of shallow soil, but is used profitably both for pastures and for the production of cedar timber.

Gray-colored soil.—In addition to the soils mentioned, certain minor areas of gray-colored soils with yellowish-red subsoils are found. They are heavier and not so fertile as the typical brown loams, and have been found to respond to both phosphate and lime. They make excellent wheat and grass lands when properly handled.

Overflow and bench lands.—The overflow and bench lands of this part of the State are in general very rich, and are not apt to require much if any artificial drainage. As in East Tennessee, the texture of the overflow lands varies greatly, depending upon the swiftness of the current at the point of deposition. Sandy soils and sandy loams are the rule. The bench lands are apt to partake of the nature of the adjacent uplands, but are deeper and richer. At the present time, the bench lands are more or less reduced in fertility, by reason of long continued cropping in corn. They should be set oftener to clover and grass, and a better rotation of crops than that commonly followed is highly advisable.

THE HIGHLAND RIM.

The Highland Rim, which completely surrounds the Central Basin, has an approximate area of 9300 square miles, and an elevation of 800 to 1000 feet above sea level. The average annual rainfall of nearly 50 inches is well distributed throughout the year. The average date of the last killing frost in the spring varies according to the locality, from April 8 to April 20. In a similar manner the average date of the first killing frost in the fall, varies from October 8 to October 26.

The surface varies from gently undulating to hilly, but in general lies well for cultivated crops. The soils may be roughly divided into two large groups, one on the outer part of the rim, consisting of those derived from the decomposition of limestone; and the other on the inner part, derived from siliceous or "freestone" formations.

Limestone soils.—Over large areas the limestone soils are readily distinguished by their dark-brown color, where recently cleared and improved, and by their red or "mulatto" color where cultivated and worn. In physical character, crop adaptability and color, this type is very similar to the high-grade limestone soils of East Tennessee. Alfalfa has done especially well on it. Other areas of limestone soils consist of grayish and brownish loams, which are often gravelly, and which have red subsoils. Some of the brown-colored soils are naturally rich, and are adapted to a great variety of crops, including tobacco. The gray soils are inferior to the others, and may be even classed with the "barrens" type, but are excellent tobacco soils.

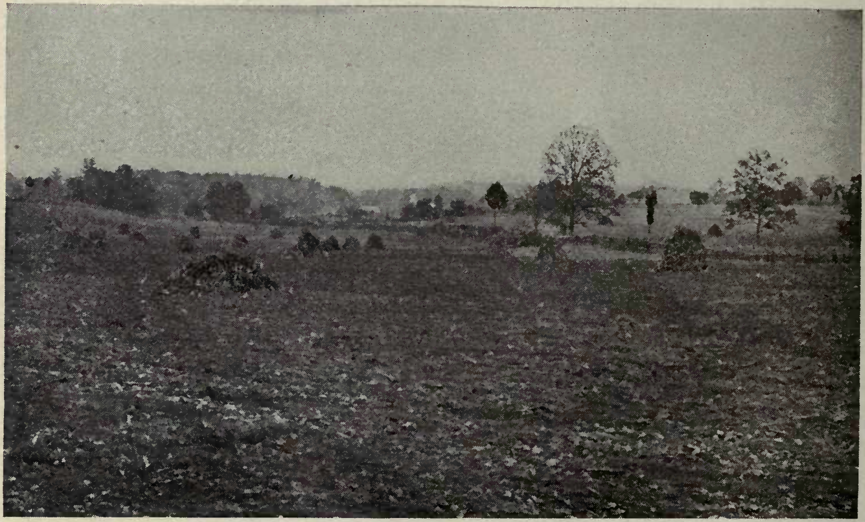


FIG. 4. View in Robertson County, northeast of Adams.

All these soils are of good depth and the drainage is adequate. Up to the present time grain farming has predominated. Tobacco has been an important crop in some counties, Montgomery and Robertson in particular. Nursery stock has been produced extensively in Franklin County and peanuts in Perry and Humphreys counties. There is every indication that the production of these special crops could be greatly increased.

The results of chemical analyses and of field experiments show that both lime and phosphoric acid are generally deficient. The better class of these soils will, however, produce excellent crops of clover when first cultivated, but in the course of time liming becomes necessary to their successful culture, and is even more important for alfalfa. The supply of potash appears fairly ample, at least for general farm purposes. The farmers long ago found out the value of phosphate, but only in the last few years has special attention been called to the importance of liming.

The nitrogen and humus content, though fair when the land was first cleared, has been greatly reduced under cultivation. As for other soils the remedy lies in the growing of legumes, alfalfa and clover in particular, and in live stock farming, which will warrant grass pastures and reduce the area now planted to grain crops.

The "barrens" type.—On the inside of part of the rim, and completely encircling the Central Basin, are found gray-colored soils, which are derived largely from siliceous formations, but in part from limestone containing much chert. There is a considerable variation in this class of soils, some being gray-colored with a gray subsoil and locally known as "crawfishy" land; others are gray-colored with a yellowish subsoil, and a third type is gray to a light-brown in color with a red-colored subsoil. The last type is considerably superior to the first or crawfishy type and is also superior to the second. The area covered by these soils is relatively large. The surface varies from gently undulating to hilly—the latter being gravelly and very poor.

These soils are silt loams of good texture and structure except where very deficient in vegetable matter. The depth to the underlying rock is ample and the drainage is generally good, but may be poor, especially on the flat, gray-colored, crawfishy type. All of these types are naturally very poor in phosphoric acid, lime, potash and nitrogen. Without the aid of phosphate the profitable production of general farm crops is very difficult. Liming comes next in importance, and is generally a necessity in order to get clover and the best results with legumes in general. Potash is much less needed than either phosphate or lime, but in field experiments has often been found to increase the yields of hay and of potatoes. Only moderate applications are needed, however. The nitrogen supply is at best insufficient and in parts quite low.

Although these soils are rated among the poorest in the State, they are, when properly fertilized, adapted to a large number of both farm and garden crops. Dark-leaf tobacco has proved to be a profitable crop and its culture is being extended. Peanuts on a commercial scale may be grown profitably. Perhaps no other part of the State is better adapted to the production of cowpeas for seed. This is due to the fact that by the aid of fertilizers cowpeas fruit abundantly on these soils, without producing an excessive growth of vine. There is some opportunity also for the developing of orcharding and small fruit culture.

Overflow and bench lands.—The overflow and bench soils of the Highland Rim are well suited to cultivation. They are generally highly productive corn lands and are much superior to the uplands in fertility. In Perry and Humphreys counties in particular, the lowlands have been used extensively for peanut production, and are rated of high value.

WEST TENNESSEE.

Uplands.—West Tennessee slopes gradually from the Highland Rim on the east to the Mississippi River on the west. The elevation above sea level varies from 400 to 600 feet. For the most part the surface is gently undulating, and the hilly sections are characterized by lower and more rounded hills than those found in the other parts of the State. Nearly all of the soils are derived from geological deposits which were never consolidated into rock. Most of them are silt loams containing no gravel. Naturally they were well supplied with all of the elements of plant food, but under cultivation they have, with some exceptions, become poor in nitrogen and humus. This result has come about partly by the kind of

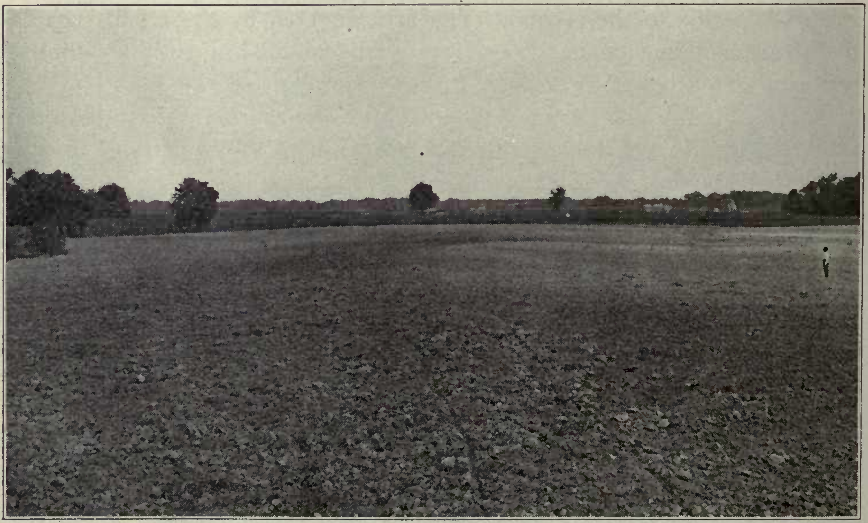


FIG. 5. West Tennessee landscape.

farming generally followed, and partly because the soils wash badly during heavy rains. In fact no large area in the State has suffered from erosion so much as this. In color the upland soils vary from a light red to gray and brown.

In the writer's opinion the soils of no other division of the State are in general so well adapted to a great range of farm and garden crops or so responsive to judicious treatment as these.

The loess soil.—Perhaps one-fourth of the total area of West Tennessee is covered by a loess formation, which extends in a belt 20 to 25 miles wide, across the western end of the State and parallel with the general course of the Mississippi River. The soils are brownish loams, which lie well for agricultural purposes, are readily tilled, and are adapted to all crops. A rather high content of silt characterizes these soils, which are of great natural strength and fertility. Even after long cultivation in cotton and corn, with the attendant loss by erosion, and with little regard to crop rotation, manuring, etc., profitable crops are obtained. In the improvement of such lands, liming and the production of legumes, the clovers in particular should receive special attention.

The Lagrange soils.—The Lagrange formation covers about one-third of West Tennessee, and occupies a belt 35 miles wide next to and parallel with the loess formation. The major portion of this area is gently undulating, but hilly areas are prominent. The soils of the latter are thinner and have suffered more from erosion than the former.

The typical soil is a grayish-brown silt loam with a yellowish-colored subsoil. Considerable variation is not uncommon on the same farm, for the grayish-brown loam is often replaced, especially on the lower levels, by a gray-colored, very silty soil, resembling in general appearance the "crawfishy" soils of Middle and East Tennessee. Both of these types have been the subject of investigation at the West Tennessee Agricultural Experiment Station at Jackson, and both have been found to be well supplied with phosphoric acid and potash. The grayish-brown loam was found to be very poor in lime, by the adding of which excellent crops of clover and alfalfa were obtained, while without it they were complete failures. This type was naturally very fertile, but long cropping in cotton and corn, together with the attendant erosion, which is more serious than for the loess soils, have greatly reduced the productiveness. However, the readiness with which it responds to good treatment is very striking.

The gray "crawfishy" soils have proved to be considerably superior to soils of similar appearance found elsewhere in the State. Their chief drawback comes from the ease with which the surface soil grains cement together during heavy rains, so that the excess of water is not readily absorbed and the drainage is apt to be poor. On the Jackson farm this type has proved to be very little in need of lime or of any other mineral element. Excellent crops of Japanese clover, peanuts, red clover and alfalfa were obtained with little difficulty. In contrast with the good supply of the minerals, the nitrogen and humus supplies are very low. This kind of soil therefore is not well suited to grain crops, and non-legumes in general, but may be used to much advantage both for pastures and for the production of legumes.

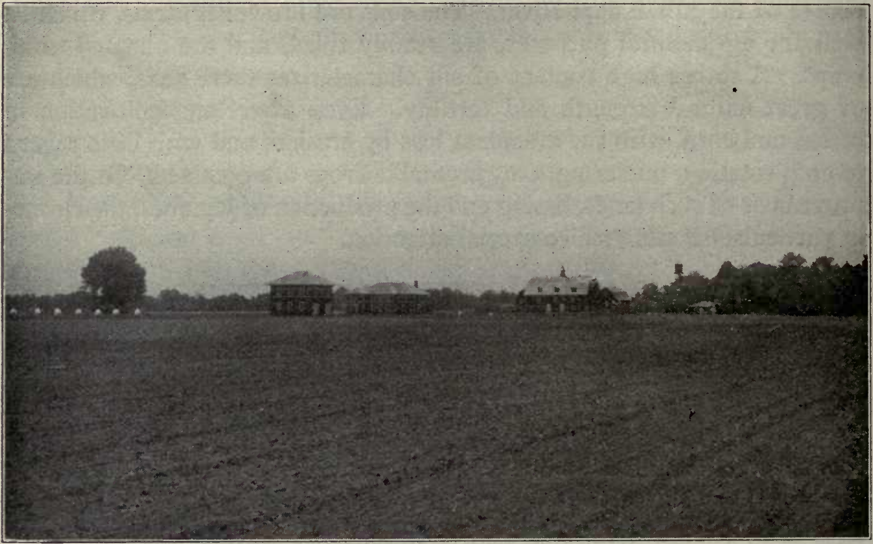


FIG. 6. West Tennessee Experiment Station.

Another common type of soil is reddish-colored. It is said to be by nature fully the equal of the grayish-brown loam. No experimental work has, however, been done on this soil by the Station, so that its specific mineral plant food requirements are not known to the writer. This type is light, easily tilled and contains more sand than the grayish-brown loams. It is suitable to all common farm and garden crops, but erodes very easily, so that it is apt to become poor in nitrogen and humus.

Miscellaneous soils of the eastern section of West Tennessee.—The remaining undescribed portion of West Tennessee, or about one-third of the whole, extends in a somewhat triangular belt across the State from north to south, and borders the Tennessee River in its flow to the north. The width of this belt on the Mississippi line is about sixty miles and on the Kentucky line about fourteen miles. Eight geologic formations are represented within this area, but the major portion of it is covered by only four, which run in narrow parallel belts across the State.

Although there is considerable variation, the soils of this section are in general not equal for agricultural purposes to those of the loess and Lagrange areas. For the most part, they are silt loams of fair natural fertility and suited to the usual crops of the climate; but much of the area has suffered very severely from erosion and the continued production of cultivated crops. Much of the county is hilly and the eastern edge is a continuation of the Highland Rim of Middle Tennessee. The specific plant food requirements of the various soils have not been worked out, but both liming and phosphating are apt to be beneficial, and the need of increased supplies of nitrogen and humus is evident. Considerable areas are better suited to pasture and timber than to cultivated crops.

Bottom and bench lands.—Overflow lands in West Tennessee are comparatively little used for farming purposes, the major part being in timber. The reason for this condition, which is so different from that found elsewhere in the State, is that special drainage systems are necessary in order to warrant cultivated crops. The overflow lands form fairly wide margins along the streams, the channels of which are not large enough in this gently sloping country to carry off the surplus waters from the large areas drained. In addition, while the bottom lands are richer than the neighboring uplands, they do not as a rule have the high fertility of the bottom lands of the other sections of the State. Rather large areas of gray-colored silty soils occur, and where the leaves and other loose material have been swept away from year to year by the floods the soil may be very deficient in humus matter.

These bottom lands are valuable chiefly for their timber, but in addition furnish some grazing for cattle. State laws are favorable to comprehensive drainage projects which have been carried out successfully in some counties, and are in progress in others. The increased value of the reclaimed lands for pasture purposes alone is probably worth all the expense incurred by drainage. Also a considerable portion makes highly productive land for the usual farm crops.

Along the Mississippi River there are some alluvial lands of very great fertility, comparable with the best found anywhere in the world. All the common crops are grown, including alfalfa, which thrives without attention to either liming or manuring.

In the northwestern part of West Tennessee, especially in Obion County, occur rich valley lands which are very durable under cultivation. The soils are dark-colored silt loams and have a moderately high content of humus. For the most part they require tile drainage. These soils are excellent for corn, clover and grass, and also for alfalfa. They appear to be fairly well supplied with all of the plant food elements, even alfalfa being grown to some extent without liming. However, liming is apt to give increased yields of alfalfa and frequently its need is indicated by the litmus test. In no other part of the State is red clover so common and successful a crop, and as long as this is the case profitable crops of all kinds may be expected.

REFERENCES TO LITERATURE ON TENNESSEE SOILS.

The publications from the Agricultural Experiment Station of the University of Tennessee, Knoxville, are as follows:

MOOERS, C. A.

1. Experiments with fertilizers and farm crops on important soil types of Middle Tennessee.
   Bulletin 92 (1911).
2. Fertility and crop experiments at the West Tennessee Station.
   Bulletin 109 (1914).
3. Liming for Tennessee soils.
   Bulletin 97 (1913).
4. The rational improvement of Cumberland Plateau soils.
   Bulletin 101 (1913).
5. The rational improvement of Highland Rim soils.
   Bulletin 102 (1913).
6. The soils of Tennessee, their chemical composition and fertilizer requirements.
   Bulletin No. 4, Vol. XIX (1906).

VANDERFORD, C. F.
The soils of Tennessee.
Bulletin No. 3, Vol. X (1897).

The following articles have appeared in the "Resources of Tennessee:"

MADDOX, R. S.
West Tennessee gullies, lands and their reclamation.
Vol. V, No. 1, January, 1915.

PURDUE, A. H.
The gullied lands of West Tennessee.
Vol. III, No. 3, July, 1913.

ROGERS, REESE F.
The soils and agricultural resources of Robertson County.
Vol. II, No. 12, December, 1912.

The Bureau of Soils of the U. S. Department of Agriculture has published reports of surveys as follows:

Clarksville area	published in ——
Coffee County	published in 1910
Davidson County	published in 1904
Giles County	published in 1909
Grainger County	published in 1907
Greeneville area	published in 1904
Henderson County	published in 1905
Jackson County	published in 1915
Lawrence County	published in 1905
Madison County	published in 1907
Overton County	published in 1909
Pikeville area	published in 1904
Putnam County	published in 1914
Robertson County	published in 1914
Sumner County	published in 1910

Recent Oil Developments Near Oneida, Scott County, Tennessee

By L. C. Glenn.

INTRODUCTION.

Location.—Scott County is situated on the northern part of the Cumberland Plateau and has the Kentucky State line as its northern boundary. Oneida is in the north-central part of the County on the C., N. O. & T. P. railroad, and the recent oil developments have been about four miles northwest of town. Two wells are now drilling in town and a number of other locations have been made especially to the north and west of the town, as may be seen from the accompanying map, Fig. 1. Some of these located wells will probably be drilling and other locations will doubtless have been made before this report is published.

Basis of report.—The work of the writer, for the past few summers, on the coals of the northern part of the Cumberland Plateau has made him familiar with the general geology of Scott County and the adjacent region. In June a week was spent in the field studying the geology with especial reference to the occurrence of oil and a second visit was made to the field in mid-August. Mr. Henry F. Bain was employed to collect samples of the borings from the West No. 1, Toomey No. 2 and Hendren No. 1 wells. The accompanying logs and plotted sections of these three wells have been made from these samples, while the logs of Toomey No. 1 and Easter No. 1 wells have been taken from the drillers' records.

The materials collected by Mr. Bain have been carefully studied and compared with each other by the writer and chemical analyses of certain of the "sands" have been made by Dr. Bowers in the laboratory of the Survey. Analyses of the oil have been made both by Dr. Bowers and by the U. S. Bureau of Mines.

Acknowledgments.—The writer is especially indebted to Mr. Chas. W. Whitcomb, Mr. J. P. Hambrick, the Syndicate Oil and Gas Company, and the drillers of the three wells, sampled by Mr. Bain, for drillers' logs and facilities and aid in collecting samples as well as for much general information as to activities in the field. He is also greatly indebted to Mr. Bain for the care with which the samples were collected.

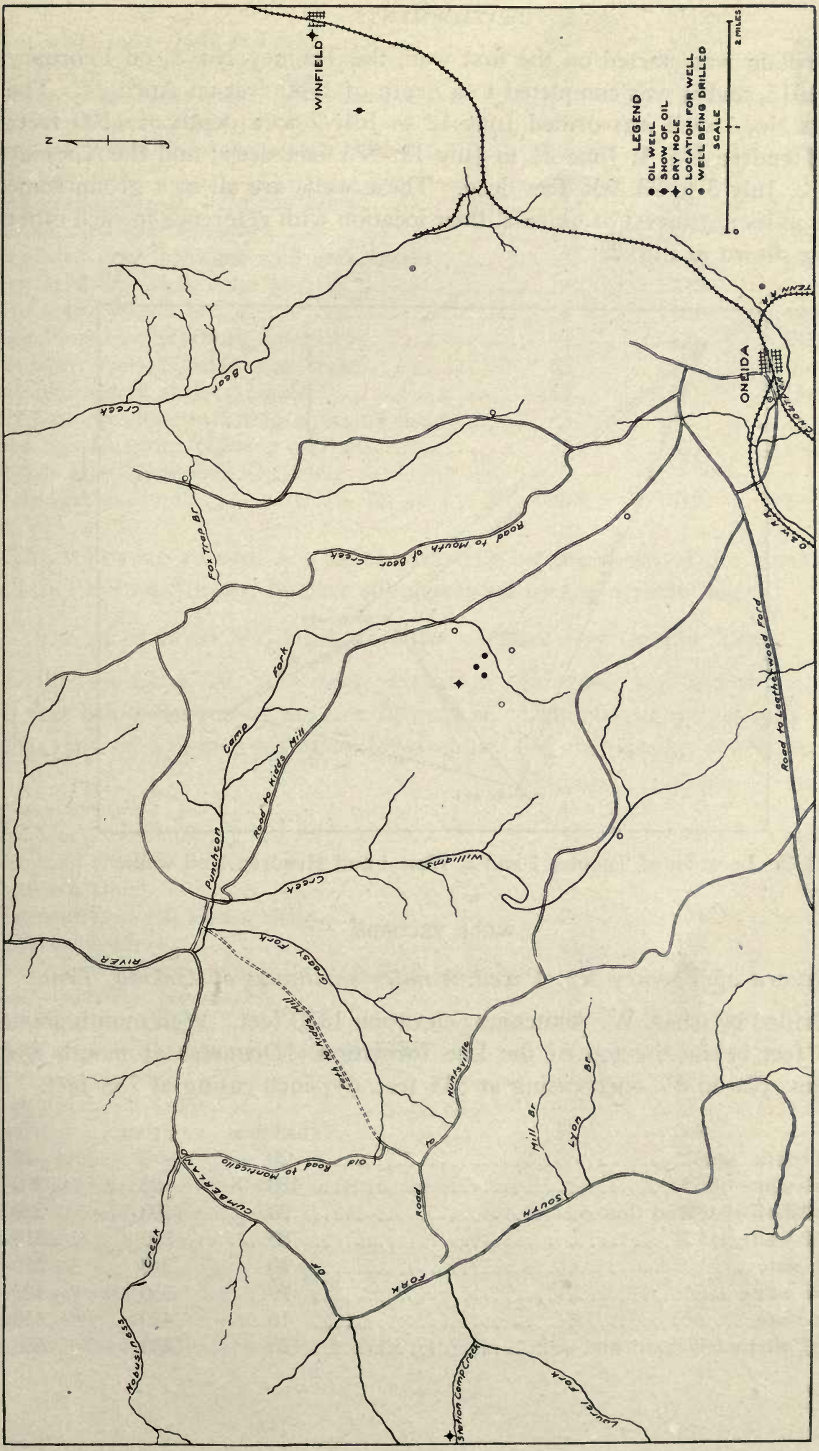


FIG. 1. Sketch map showing location of oil wells.

DEVELOPMENTS.

Drilling was started on the first well, the Toomey No. 1, on February 20, 1915, and it was completed to a depth of 1700 feet on April 27. The West No. 1 well was drilled June 12 to July 7 to a depth of 1100 feet; the Hendren No. 1, June 21 to July 13, 973 feet deep; and the Toomey No. 2, July 3 to 23, 965 feet deep. These wells are all in a group some four miles northwest of Oneida, their location with reference to each other being shown in Fig. 2.

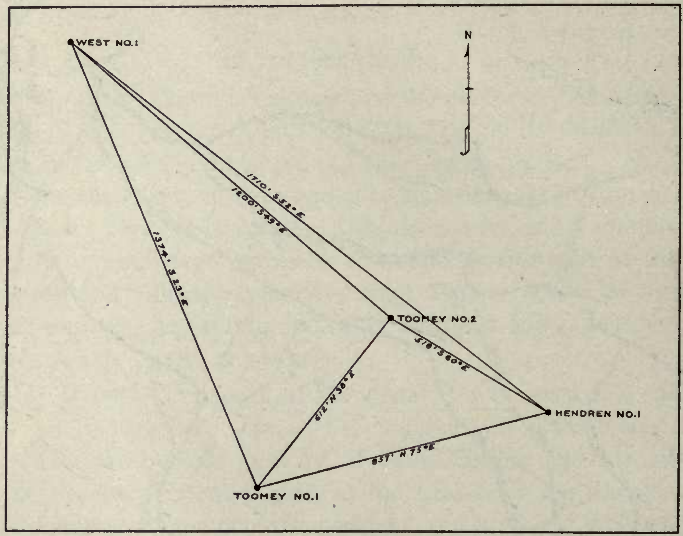


Fig. 2. Location of Toomey 1 and 2, West 1 and Hendren 1 oil wells.

WELL RECORDS.

Record of Toomey No. 1 well, 4 miles northwest of Oneida, Tenn.

Drilled by Chas. W. Whitcomb; elevation 1320 feet. Well mouth about 220 feet below the top of the Lee formation. Diameter at mouth 8¼ inches; placed 8¼-inch casing at 335 feet, 6¼-inch casing at 788 feet.

	Thickness	From	To
Soft dark sand	20	0	20
Hard white sand	180	20	200
Hard dark slate and thin coal	30	200	230
Hard white sand	80	230	310
Soft slate	40	310	350
Hard white sand	70	350	420
Soft slate	10	420	430
Slate, alternately hard and soft	120	430	550

	Thickness	From	To
Hard white sand (base of Lee)	60	550	610
Soft red slate, caving (Pennington)	140	610	750
Hard gray limestone (top of Newman)	195	750	945
Gray limestone, sandy, fairly soft—the oil "sand"	20	945	965
Gray and brown limestone, mostly hard	331	965	1296
Soft blue slate	10	1296	1306
Dark gray limestone, hard and gritty	71	1306	1377
Pinkish crystalline limestone	19½	1377	1396½
Very hard gray limestone with dark specks	2	1396½	1398½
Very hard limestone, color varying	19½	1398½	1418
Hard white limestone	12	1418	1430
Hard limestone, brownish (Beaver?)	45	1430	1475
Soft black shale (Chattanooga shale)	65	1475	1540
Soft bluish-gray shale (Osgood?)	15	1540	1555
Soft blue limestone with thin layers of shale	45	1555	1600
Hard blue limestone (Clinton or Hudson?)	35	1600	1635
Grayish blue limestone, alternately hard and soft (Hudson?)	65	1635	1700

The following records are based primarily on the study of the borings collected by the Survey, but are supplemented by the drillers' logs.

Record of West No. 1 well, 4 miles northwest of Oneida, Tenn.

Drilled by Chas. W. Whitcomb; elevation 1357 feet; well mouth about 180 feet below the top of the Lee formation. Diameter of well mouth 10 inches; placed 8¼-inch casing at 348 feet and 6¼-inch casing at 889 feet.

	Thickness	From	To
Surface material	45	0	45
Hard blue sandy shale	30	45	75
Dark sand-shale	5	75	80
White sandstone	94	80	174
Silty sandstone and leaden shale	11	174	185
White sandstone	11	185	196
White sandstone with dark shale partings, a sand-shale	6	196	202
Blank—probably sandstone	8	202	210
Sandstone	120	210	330
Thinly laminated sandstone, shale partings	11	330	341
Dark sandy shale	21	341	362
Blank—probably sandstone	6	362	368
Sandstone	97	368	465
Blank—probably sandstone	23	465	488
Laminated sandstone with dark shale partings	5	488	493
Blank—probably shale	6	493	499
Dark shale	5	499	504
Sandstone	33	504	537
Dark laminated sand-shale	19	537	556
Dark shale	5	556	561
Thin laminated sandstone with dark shale partings	33	561	594

	Thickness	From	To
Fine white sandstone	5	594	599
Dark shale (base of Lee)	6	599	605
Limestone (top of Pennington)	5	605	610
Red, green and dark shales	89	610	699
Red and green shale with some limestone	6	699	705
Shales, dark slate colored	16	705	721
Blank (shales)	6	721	727
Red, green, and dark slate-colored shales	7	727	734
Red and green shales	42	734	776
Dark shales	18	776	794
Dark shale and light gray limestone	6	794	800
Red, green and dark shales	40	800	840
Gray limestone	8	840	848
Brown, sandy limestone, oil-bearing	5	848	853
Gray limestone with shale probably from caving	15	853	868
Oölitic limestone	10	868	878
Dark gray limestone, some dark and red shale partings	52	878	930
Limestone, brown and dark gray, crystalline	65	930	995
Brownish gray, compact, fine-grained limestone	45	995	1040
Brownish-gray crystalline limestone	15	1040	1055
Brownish-gray, compact, fine-grained limestone	17	1055	1072
Brownish-gray, crystalline limestone	6	1072	1078
Light gray crystalline limestone	6	1078	1084
Brownish-gray crystalline limestone	16	1084	1100

Record of Hendren No. 1 *oil well,* 4 *miles northwest of Oneida, Tenn.*

Drilled by Chas. W. Whitcomb. Elevation 1298 feet; mouth of well about 240 feet below the top of the Lee formation; diameter at well mouth 8¼ inches; 8¼-inch casing to 335 feet; 6¼-inch casing to 788 feet.

	Thickness	From	To
Sandstone	205	0	205
Dark shale	5	205	210
Sandstone	12	210	222
Sandstone, with some black shale	5	222	227
Sandstone, with occasional coal particles	58	227	285
Dark shale	20	285	305
Dark sandy shale and fine sandstone	15	305	320
Dark shale	15	320	335
Blank	6	335	341
Sandstone, water at 374	61	341	402
Dark shale	22	402	424
Sandstone, with some sandy shale partings	60	424	484
Dark shale	6	484	490
Dark, laminated sandstone	5	490	495
Dark shale, part sandy	11	495	506
Laminated sandstone	5	506	511

	Thickness	From	To
Sandstone with shale partings, signs of coal near bottom	20	511	531
Blank—probably sandstone	23	531	554
Sandstone (base of Lee)	6	554	560
Red and green shale (top of Pennington)	28	560	588
Red and green shale, with some limestone	6	588	594
Red, green and dark shale	48	594	642
Red and dark shales and some dark limestone	6	642	648
Dark limestone, fine-grained	7	648	655
Red and dark shales, with thin limestones at 676 and 697	93	655	748
Light gray limestone	3	748	751
Dark shale	6	751	757
Dark limestone	7	757	764
Dark and red shale	6	764	770
Dark limestone	40	770	810
Gray limestone with some fine gray siliceous dolomite	5	810	815
Gray limestone	11	815	826
Oölitic limestone	6	826	832
Dark crystalline limestone with some gas at 845 and some dark shale at 881	83	832	915
Gray crystalline limestone with some dark shale with show of oil at 930	25	915	940
Very compact brownish limestone, with lower half as top of oil "sand"	10	940	950
Brownish and gray finely granular limestone, with some shale partings (or caving?), with oil "sand" down to 968	23	950	973

Record of Toomey No. 2 oil well, 4 miles northwest of Oneida, Tenn.

Drilled by the Syndicate Oil and Gas Company. Elevation 1352 feet. Well started about 190 feet below the top of the Lee formation. Diameter at mouth 10¼ inches; 8¼-inch casing placed at 345 feet; 6¼-inch casing at 800 feet.

	Thickness	From	To
Surface materials	12	0	12
Soft shale and blue clay	5	12	17
Laminated sand and dark shale, mixed	29	17	46
White sandstone, with dark sand-shale at 217-224	199	46	245
Dark sandy shale	5	245	250
White sandstone	89	250	339
Dark sandy shale with some thin sandstone	56	339	395
White sandstone with occasional thin shale partings	71	395	466
Dark sandy shales	17	466	483
Light and dark gray sandstone	19	483	502
Dark sandy shale	13	502	515
Gray sandstone	41	515	556

	Thickness	From	To
Dark shale	6	556	562
Dark gray sandstone	6	562	568
Dark shale	6	568	574
Sandstone, with some dark shale (base of Lee)	40	574	614
Gray limestone (top of Pennington)	14	614	628
Red and green shale, with thin limestone at 717	107	628	735
Dark slate-colored shale	14	735	749
Red and green shale	56	749	805
Light gray limestone	10	805	815
Dark shale with occasional thin limestone	45	815	860
Brown saccharoidal dolomite, fine-grained, oil-bearing	5	860	865
Dark limestone, and some brown dolomite	5	865	870
Dark limestone	5	870	875
Oölitic limestone	5	875	880
Dark gray limestone	65	880	945
Fine brown dolomitic limestone, saturated with oil, had some gas	5	945	950
Fine dark-gray limestone	5	950	955
Brownish-gray crystalline limestone with top of oil "sand" reached at 960	10	955	965

Correlations.—While the general geology will be discussed on a later page, it may be well to point out here certain correlations in the above records.

In each well a number of the samples above the first red shale, or first plainly evident limestone, were tested chemically for limestone so that the boundary between the Lee and the Pennington is fixed with certainty. In the Toomey No. 2 and the West No. 1 wells the top of the Pennington is limestone, but in the Hendren No. 1 well it is red and green shale.

Beneath about 200 feet of Pennington shale there appears in each of the three wells a very light gray or almost white limestone that must be at the same horizon. Between 50 and 60 feet lower in the Toomey No. 2, at a depth of 860-865, and in the West No. 1 at 848-853 depth there appears a very fine-grained saccharoidal brown magnesian limestone (see analysis No. 2), that is undoubtedly the same in each well. This bed is very inconspicuous in the Hendren No. 1 well, but it is believed that it is represented by some fine gray material, not oil-bearing, at 810 to 815.

In each well an oölitic limestone appears ten or fifteen feet below this fine magnesian limestone. In the Hendren No. 1 well it is found at 826 to 832, in the Toomey No. 2 at 875 to 880, and in the West No. 1 at 873 to 878. The position of these different beds is indicated in the columnar sections in Fig. 3, and their importance will become obvious in the discussion of the structure on a later page.

WELLS DRILLING.

At Oneida the Easter Oil and Gas Company's well No. 1 began drilling August 3. It is located about a half mile southeast of town at an elevation of 1481 feet. The well mouth is 80 or 90 feet above the top of the Lee formation, though the following log, as given by the drillers, fails to note the sandstone that forms the top of the Lee. This sandstone is struck in water wells in town at a depth of 20 to 40 feet, and in the water well at the Oneida and Western Railway shops it was penetrated to a depth of 90 feet without reaching bottom. It is possible, though hardly probable, that this thick sandstone has changed to shale in the three-fourths of a mile interval between the two wells. The depth to the Almy or Bear Creek coal was not definitely noted in the Easter well, but was given as "somewhere about 90 feet." This coal crops out in the south edge of town and should be only about 50 or 60 feet deep in the well.

Record of Easter Oil and Gas Company's well No. 1 *at Oneida, Tenn.*

	Thickness	From	To
Soft gray shale, with 12-inch coal at about 90 feet (probably 50 or 60 feet instead)	300	0	300
White sandstone	55	300	355
Black slate	35	355	390
White sandstone	70	390	460
Black slate	20	460	480
White sandstone	45	480	525
Black slate	5	525	530
White sandstone	120	530	650
Black slate	5	650	655
Sandstone with water	40	655	695
Coal (and shale?)	5	695	700
Hard black slate	30	700	730
Soft black shale	145	730	875
Hard black slate and sand	10	875	885
White sandstone	15	885	900
Soft black slate	55	900	955
White sandstone (base of Lee)	35	955	990
Limestone (top of Pennington)	10	990	1000

In addition to the foregoing well, another, the Anderson No. 1, is being drilled in the western edge of Oneida by the Oneida Oil and Gas Company. This one was down only a few hundred feet in the Lee formation when visited and so no record was obtained.

WELLS LOCATED.

A number of other locations have been made and in mid-August preparations for drilling were being made. The position of these future wells may be seen from the accompanying map, Fig. 1.

WELLS DRILLED IN ADJACENT TERRITORY.

A number of wells have been drilled in adjacent territory, brief reference to which would seem desirable here.

Winfield well.—This well was drilled in 1905 on the L. E. Bryant property at Winfield, some 250 yards west of the depot. Its elevation is about 1343 feet, and the mouth of the well is just about the top of the Lee formation. The record as given by Munn* is as follows:

Record of Bryant well, Winfield, Tenn.

Coal No. 3, at 100 feet; Coal No. 1, 5 feet, at 525 feet.

	Thickness	From	To
(Lee formation)	900	0	900
Pennington shale	90	900	990
Newman limestone	375	990	1365
Sandstone(?) (Newman limestone and Waverly)	300	1365	1665
Chattanooga shale	38	1665	1703
Limestone and shale to bottom	507	1703	2210

This well is reported to have gotten a sand at about 900 feet that was thought would yield a 9 to 12 barrel well. In the Beaver sand close above the Chattanooga shale some oil and gas were found and the well was shot there. After deepening to 2210 feet the well was abandoned.

The Shoally Fork or Jones well.—This well was drilled about 1899 by the Hydetown Oil and Gas Company, about 1½ miles southwest of Winfield. Its elevation is about 1378 feet and the well mouth is within a very few feet of the top of the Lee formation. The record given to the writer from memory by Mr. L. E. Bryant is as follows:

Record of Shoally Fork Well, Scott County, Tenn.

	Thickness	From	To
Sandstone	175	0	175
Thin coal (No. 3½?)	...	....	....
Sandstone	375	175	550
Coal (No. 3), reported	3 or 4	550	553
Sandstone with oil	110	553	663
Thin coal (No. 2½?)	...	....	....

---

*Bull. 2-E, Tenn. Geol. Survey, p. 20.

This lower sand was estimated to yield from 2 to 10 barrels per day. On deepening the well, salt water was encountered, and on reaming out the hole to reset the casing a string of tools was lost and the well abandoned.* Another report gives the total depth of this well as 624 feet.

Bear Creek well.—This well was started late in 1914, about four miles a little east of north of Oneida at the Bear Creek mines, but difficulties were experienced and work was stopped at a depth of 580 feet, the entire distance being in the Lee formation. The well mouth has an elevation of about 1450 feet and is at the top of the Lee formation.

Beatty well.—This well, located on the Big South Fork of Cumberland River, 2 or 3 miles north of the State line in Kentucky, was drilled about 1825 for brine. Its elevation is about 815 to 825 feet, and the top is in the Pennington shale, probably between 25 and 75 feet below the top of this shale. One report says oil in considerable quantities was encountered at a depth of about 200 feet, while another account says oil was struck 350 or 360 feet down. It is understood that this old well is to be cleaned out. A short distance west of it several wells located on the plateau surface some 500 feet higher have just been drilled and are said to have made satisfactory showings. The same parties are continuing their drilling in that region. Their wells on the plateau level are about 500 feet above water level in the river. They reach the base of the Lee at about 380 feet, get the top of the big lime (Newman) about 675, get the first pay "sand" at 700, and others at 800, 900 and 956 feet in the big lime, with the Chattanooga black shale at 1290 feet depth.

Owens well on Station Camp Creek.—This well was drilled by Cadahy Bros. of Chicago in 1896 about 1½ miles west of the South Fork of the Cumberland River on Station Camp Creek. It started in the sandstones of the Lee formation, not far above their base. Salt water was found at various depths from 200 to 550 feet. The Beaver sand, extending from about 600 to 750 feet depth, was very hard and flinty and made a small showing of oil. The total depth reached was 1515 feet when the well was abandoned.

Rugby Land Company well No. 1.—This well was drilled in 1896 by the Forest Oil Company, in the extreme southwestern edge of Scott County, a few miles northwest of Rugby Road. The well was started at an elevation of 1280 feet. There was a show of tar at 512-517 in hard white sand, and a show of dark green oil in hard white lime at 1335-1340. The detailed log given by Munn† may be briefly summarized here as follows:

---

*Munn, *op. cit.* p. 20.

†*Op. cit.*, p. 20.

Condensed record of Rugby Land Company Well No. 1.

	Thickness	From	To
Briceville shale	60	0	60
Lee formation	702	60	762
Pennington formation	208	762	970
Newman limestone (and Waverly?)	713	970	1683
Chattanooga black shale	45	1683	1728
Silurian (?) and Ordovician limestone and shale	673	1728	2401

Rugby Land Company well No. 2.—This well was drilled in 1896 by the Forest Oil Company in the extreme northern part of Morgan County and about 1½ miles south of Rugby. The well was started some 150 to 200 feet below the top of the Lee formation. A show of green oil was found in a reddish-brown sand in the Newman limestone at 1215 to 1230. The detailed log given by Munn * may be condensed as follows:

Condensed record of Rugby Land Company well No. 2.

	Thickness	From	To
Lee formation	525	0	525
Pennington formation	235	525	760
Newman (and Waverly?)	695	760	1455
Chattanooga black shale	40	1455	1495
Silurian (?) and Ordovician limestone and shale	1298	1495	2793

TOPOGRAPHY.

Drainage.—The region about Oneida is drained westward and northwestward into the Big South Fork of Cumberland River by a number of small creeks whose headwaters flow at about the general country level and are apt to have sluggish currents and to be bordered by swampy flood plains. The middle and lower courses of these streams, however, have cut below the general level of the upland surface and flow in rough canyons walled in by massive sandstone cliffs.

The river flows in a narrow canyon-like valley, a fourth to a half mile wide, cut some 500 to 600 feet below the general upland surface. The sandstone cliffs along its sides are in places 300 or 400 feet high, as for example near the mouth of Pine Creek.

Surface relief.—The region may be divided into two parts on the basis of differences in surface relief. North and west of Oneida, the country is a rolling plateau, whose surface—some 1400 to 1600 feet above sea level—is broken along the middle and lower courses of the streams by the deep and narrow gorges in which they flow. These stream gorges are usually rimmed with sandstone cliffs and their steep sides are often strewn with

---

**Op. cit.*, pp. 22-23.

large boulders. These gorges are several hundred feet in depth and are serious obstacles to any travel across them. The few roads in the region keep as much as possible up on the plateau surface and usually follow the divides between the main streams.

To the south and east of Oneida, the plateau-like character is largely lost and the country becomes hilly to mountainous, often with steep slopes and narrow stream valleys, but usually without the rugged character of the cliff-bound stream gorges of the more westerly plateau portion.

The Queen and Crescent Railway may almost be taken as the dividing line between the two types of surface, since the hilly region to the east and southeast of this road extends west of it in but a few places and for short distances only. Most of the region is wooded. Farms, especially on the plateau part, are few and small.

GEOLOGY.

The rocks of the region consist of sandstones, shales and limestones that are grouped into a number of formations, the three youngest of which are exposed at the surface either in the vicinity of the wells or a few miles west of them in the bottom of the lower courses of the larger stream gorges and along the Big South Fork River. Several of the older formations reached by the drill do not appear at the surface in this immediate region, but are well known as surface formations both east and west of here.

SURFACE FORMATIONS.

Briceville shale.—The youngest rocks of the region that have been penetrated by the drill so far are a series of soft shales with subordinate sandstones, known as the Briceville shale. These rocks form the surface of the hilly or southeastern portion of the region as above described. About 30 or 40 feet above their base they contain a coal that has been mined at Helenwood, Almy, Bear Creek and elsewhere. West of Oneida these shales remain mostly in more or less isolated patches that disappear entirely in a few miles to the west of town and leave the surface composed of the rocks of the next underlying formation, which is known as the Lee. To the east of Oneida, the Briceville shales are overlaid on the higher peaks and ridges by later formations that, like the Briceville, are also of Pennsylvanian age.

Lee formation.—Immediately under the Briceville shale there come a series of sandstones and shales some 700 to 900 feet thick known as the Lee formation. The sandstones are usually massive and in places are conglomeratic. The shales are subordinate in amount and generally dark gray to almost black in color. At several places the drillings show particles of coal, though in the Toomey-West-Hendren group of wells, it was not certain that the coal was of commercial thickness. In the Easter well several feet of coal were found at a depth of 695 feet. In detail, the thickness of the individual beds of sandstone and shale vary rapidly so that sections made at even short distances apart may fail to match except in a broad general way. Examples of such variation may be seen in the plotted sections given in Fig. 3. The total thickness of the Lee formation at the group of wells four miles northwest of Oneida varies from 785 to 804 feet for the three wells whose cuttings were examined by the writer. In the Toomey No. 1 the thickness as deduced from the driller's record is 830 feet. To the east the Lee is known to thicken considerably and in the Easter well at Oneida it is 900 feet or slightly more in thickness. To the west it becomes gradually thinner. The Lee forms the base of the Pennsylvania or Upper Carboniferous.

Pennington shale.—The top of this formation is marked either by a few feet of limestone or by red and green shales. The top of these shales is soft and often gives the drillers trouble by caving. In them there are occasional thin beds of limestone and in their middle and lower parts much of the shale is dark slate colored and breaks into long prismatic or pencil-like pieces. The thickness of the Pennington in the Hendren well is 188 feet, in the West well 189, and in the Toomey No. 2, 191. In the Rugby Road and Rugby wells it is 208 and 220 feet respectively, while in the Winfield well it is reported as only 90 feet.

It is known that after the Pennington was deposited this whole region was uplifted and its surface was subjected to a prolonged period of erosion before it sank again and the materials of the Lee began to be laid down upon it. This erosion doubtless removed more of the Pennington in some places than in others and left its upper surface irregular, and the thickness of the part remaining, variable.

The Pennington appears at the surface only along the Big South Fork River and the lower mile or two of the courses of its principal tributaries.

The Pennington shale forms the top of the Mississippian or sub-Carboniferous in this region.

UNDERGROUND FORMATIONS.

The following formations do not appear at the surface in this immediate vicinity but are encountered in the deep wells.

Newman limestone.—Beneath a considerable interval of red and dark shales there appears in the Oneida region a very light, almost white, limestone that is here taken as the top of the Newman limestone. Beneath it there is a variable succession of limestone and red and dark shale beds

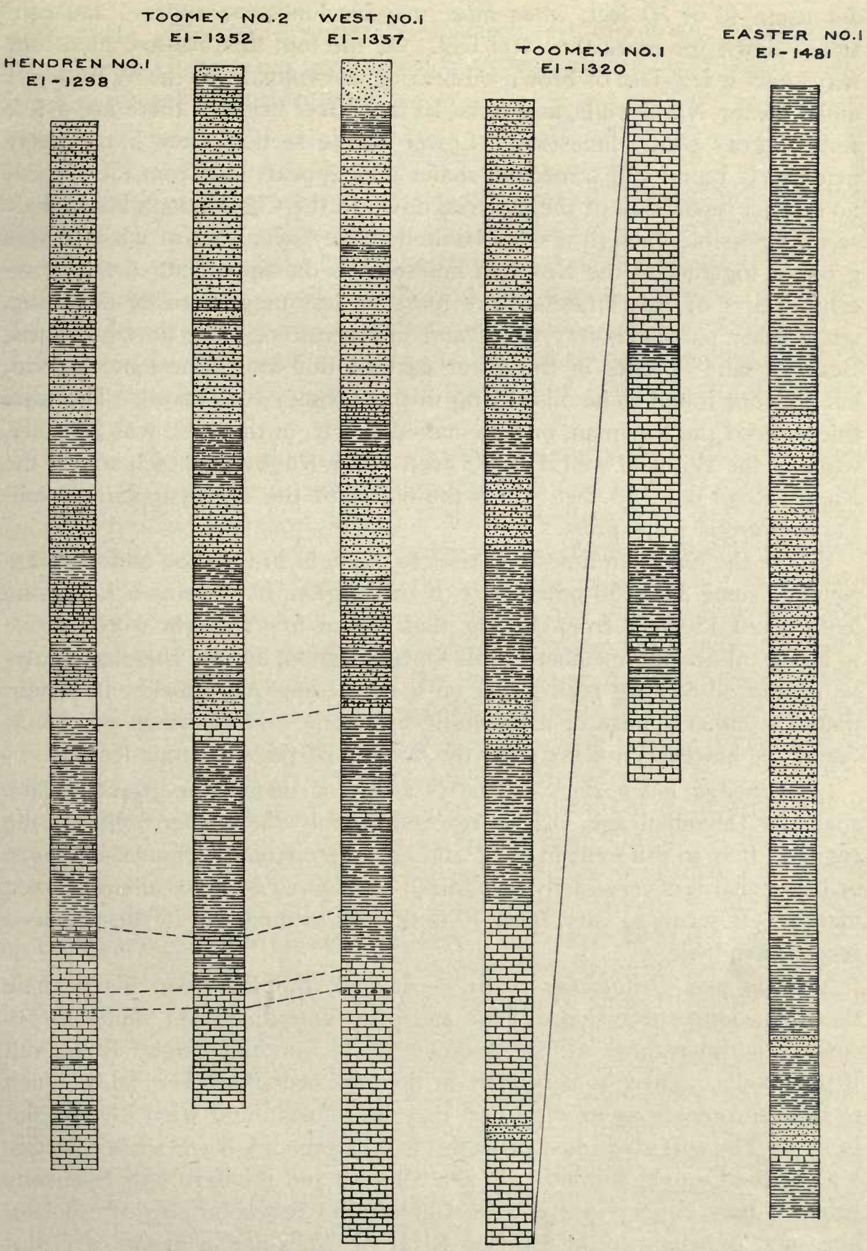


FIG. 3. Sections of oil wells in Scott County. Scale, 1 inch=178 feet.

for some 40 or 50 feet, when more massive limestone appears and continues down for more than 600 feet. At the top, this massive limestone may show a few feet of brown oil-bearing dolomite, as in the West No. 1 and Toomey No. 2 wells, and some 10 to 20 feet below it there are a few feet of gray oölitic limestone. Lower in the section some hard cherty material is found and some thin shales may appear, but from the records no distinct separation of the material down to the Chattanooga black shale seemed possible, though it is probable that the lower part of what is here grouped together as the Newman limestone is the equivalent of the Waverly. Parts of this limestone are more or less magnesian or dolomitic, while other parts are very dense and fine-textured. The horizon of the Beaver "sand" occurs in the lower part of this long limestone interval, but was not found to be oil-bearing in the Toomey No. 1 well. The total thickness of the Newman, or Newman-Waverly, in that well was 725 feet, while in the Winfield well it is 675 feet, in the Rugby well 695, and in the Rugby Road one 713 feet. It is the oldest of the Mississippian or sub-Carboniferous formations.

Where the Newman limestone rises to daylight in Overton and Fentress counties some 35 to 50 miles west of this region, it contains a sandstone lentil about 150 feet from the top, that was at first thought would prove to be the oil-bearing member in this Oneida region, but the chemical analysis of the oil-bearing rock given on a succeeding page makes it certain that it is either a pure or a dolomitic limestone. The horizon of the oil "sand" is, however, not far from the horizon of the sandstone lentil.

Chattanooga black shale.—This is a homogeneous fine-grained black shale, of Devonian age, that is reached in only the deeper wells of the region. It is so different in color and character from the materials above or below that it is very easily recognized and serves as an excellent horizon marker. It seems to vary from 40 to 65 feet in thickness in the few well records available.

Silurian and Ordovician rocks. — Beneath the Devonian black shale there is a long succession of blue and gray limestones and shales as recorded in the records of the Toomey No. 1 and the Rugby Road and Rugby wells. There is very little in these records, however, upon which to base an opinion as to what part may be Silurian and what Ordovician in age. The soft shale just beneath the Chattanooga black shale may belong to the Osgood formation of the Silurian and the hard blue limestone below it may either represent the Clinton and hence be also of Silurian age, or may belong to the Hudson River or Cincinnatian group of Ordovician age. Somewhat farther east at Elk Valley and along the Cumberland front the Clinton contains a red fossil iron ore that should be carefully looked for in wells that penetrate any distance below the Devonian black shale. This red iron ore has not been recorded in any of the wells whose records are given here, but it is present in some deep wells somewhat northeast of this region.

STRUCTURE.

The broad general features of the structure of the region are simple and easily grasped. From a synclinal axis that lies a score or more miles to the east of Oneida and runs northeast and southwest parallel to the general trend of Pine and Cumberland mountains, the rocks rise gently but persistently to the westward for many miles. This westward rise is maintained in fact until the axis of the Cincinnati-Nashville uplift is reached some 50 or 60 miles beyond the western edge of the Cumberland Plateau.

It is not probable that this rise to the west or west-northwest is substantially at a uniform rate, though the evidence to firmly establish this point is lacking at present, largely because, for the region west of Oneida, there are no good maps or well-established bench marks to give elevations that would enable the details of the structure to be readily determined. Some level lines have been run by Mr. Chas. W. Whitcomb from Oneida to his group of wells northwest of town and from these it is shown that the base of the Lee or the top of the Pennington, rises westward between these points at the rate of 40 to 50 feet per mile. Whether the direction between these points is that of the maximum rise for the region can not yet be known, but if not it is probably not far from it.

While the *base* of the Lee rises at the rate of 40 or 50 feet per mile as above given, the *top* of the Lee as traced from Oneida to the Toomey wells does not rise over 30 feet per mile, thus showing that a thickening in the Lee to the eastward occurs either within the body of the formation or, as some prefer to think, at its base. It is hoped that the logs of some of the wells soon to be drilled may throw more light on the way in which this change in the thickness of the Lee occurs, since it bears directly on determining the structure of the rocks beneath the Lee.

The contact between the Lee and the Pennington is marked, as has been stated, by an old erosion surface resulting from a period of uplift and erosion, or as it is generally called, by an unconformity. This unconformity will doubtless add to the difficulties of determining, from the structure of the Lee as revealed at the surface, what the exact structure of the rocks below the Pennington may be, and yet it is believed that the essential features of the structure of these lower rocks may be determined by careful work on the surface rocks.

What secondary structural features may be superposed upon the broad general westward rise of the rocks is not known. It has been thought by some that the rocks in the West No. 1 well indicated that instead of the usual rise of the rocks to the west, there was a reversal of dip between it and the Toomey and Hendren wells, but the logs of these wells as plotted in Fig. 3 fail to bear out this idea, but show instead a westward *rise* of the rocks from the Toomey No. 2 well to the West No. 1 as is consistently indicated by the base of the Lee, the top of the Newman, the brown oil sand and the oölitic limestone, the positions of all of which are given in the figure. The relative positions of these wells are given in Fig. 2. From the Hendren No. 1 well to the Toomey No. 2 there is a slight westward dip that would probably aid in arresting the movement of any oil that might be migrating up the general dip. Unless there is a continuation of this reversed dip east of the Hendren No. 1 well, it would not be sufficient to completely trap the oil, since the reversal shown in these wells amounts to less than the thickness of the oil sand.

In the Wayne County, Kentucky, oil fields there are very plain indications of a secondary structure consisting of a cross wrinkling or corrugation, as it were, with its axes running in the general direction of the dip of the major structure of the region, and such secondary structure may also characterize this region.

There is some evidence from the surface rocks about the Toomey wells, and for a distance of about a mile back toward Oneida that the broad general westward rise of the rocks previously spoken of, has been partially arrested, and that this group of wells, especially the Toomey Nos. 1 and 2 and the Hendren No. 1 have been drilled on a structural terrace.

In some places in this general region a slight doming occurs, as is shown in some coal seams, but no work has been done around these oil wells to show either the presence or absence of a structural dome about them.

THE OIL SAND.

Microscopic examination shows that the oil "sand" is not a sandstone as it was at first thought it might prove to be. The two "sands" that appear porous when examined with a hand lens are the siliceous magnesian limestones at 848 to 853 feet depth in the West No. 1 well and at 945 to 950 feet in the Toomey No. 2 well. The oil "sand" from 946 to 964 feet in the Hendren No. 1 well is almost a pure limestone.

The analyses of these samples are given in the following table:

Analyses of oil-bearing "sands."

Well	Toomey No. 2.	West No. 1.	Hendren No. 1.
Depth	945-950	848-853	946-964
Insoluble siliceous matter	16.06	9.09	3.09
Al_2O_3 and Fe_2O_3	4.23	1.97	0.58
$CaCO_3$	61.69	58.77	94.86
$MgCO_3$	16.74	30.09	0.19
Loss	1.28	0.08	1.28
	100.00	100.00	100.00

It is believed that the production in the Toomey Nos. 1 and 2 and the Hendren comes from a jointed or slightly fissured or fractured limestone, either pure or dolomitic. From a comparison of the logs of the Toomey No. 2 and the Hendren No. 1 it seems probable that this fissured oil-bearing limestone is not at exactly the same horizon in the two wells, and that the oil does not come from the same identical beds. The oil-bearing rocks in the Toomey No. 2 well appear to be 40 or 50 feet higher stratigraphically than in the Hendren No. 1 well, and it is possible that if the former well were deepened some 50 feet a second pay might be struck. This fissuring or fracturing is probably not far from the same horizon in neighboring wells, but that it is not universal is shown by the failure to find a pay sand in the West No. 1. It is possible that wells several miles apart may find considerable variation in the stratigraphic horizon at which fissured or dolomitized oil-bearing rocks occur, and until the character and oil-bearing features of these Newman limestones become better known, it would be desirable for future wells that fail to secure oil at about the horizon productive in the Toomey or Hendren wells, to be drilled some 100 or 200 feet deeper to test out the possibility of porous or fissured oil-bearing rocks occurring at a somewhat lower level in the Newman.

Thickness of "sand".—The thickness of the "sand" or "sands", so far as known, is about 20 to 23 feet. In the Toomey No. 1 well it is probable that a few feet below the pay there is a second pay a few feet thick; while in the Toomey No. 2 well ten feet above the main pay, there are five feet of what appears to be a good sand at 945-950.

Water.—The rocks seem to contain comparatively little water. In some of the wells no mention is made of it at all. It is possible that drilling about Oneida or east of there where the rocks are considerably lower may find more water than is found farther west if the strata contain any notable amount of water anywhere.

Gas.—Very little gas has been encountered.

Production.—No adequate tests have been made of the daily capacity of any of the wells as yet. The Toomey No. 1 was pumped from 3 to 9 hours on each of eight successive days in May and the production was at the rate of 3 to 7 barrels per hour of pumping. What production steady pumping would yield, it is impossible to say, as tanks have not been provided to take care of the oil. The Hendren well is said to have flowed some 40 barrels in a few minutes shortly after it was drilled in. The writer believes that a conservative estimate for the wells so far drilled would be from 20 to 50 barrels each per day.

Pipe line.—The nearest pipe line is in Wayne County, Kentucky, about 18 miles away. The extension to reach the Oneida region would pass by the group of wells now being drilled in Kentucky near the old Beatty well.

QUALITY OF OIL.

Oil from the Toomey No. 1 well has been analyzed by Dr. Paul C. Bowers in the laboratory of the State Geological Survey with the following results:

Analysis of oil from Toomey No. 1 *well.*

Base, paraffin.
Color, dark brown.
Gravity, 0.854 or 33.9 Baumé at 15° C or 59° F.
Begins to boil at 58° C or 136.4° F.
Flash point, —6° C or 21° F.
Burning point, 22° C or 71.6° F.
Sulphur........0.16.
Water..........None.

Fractional distillation.

Light naphtha or benzine, distilling under 150° C	17.29%
Burning oil, distilling under 150-300° C	31.14%
Lubricating oils and residuum, distilling above 300° C	51.57%

A sample was sent to the U. S. Bureau of Mines at Pittsburg. Their analysis is as follows:

Sample of oil from Toomey No. 1 *well,* 4 *miles in northwest direction from Oneida, Scott County, Tennessee.*

Specific gravity at 15° C	.8600
Specific gravity (° Be)	32.79
Viscosity (° Engler at 20° C)	2.1
Calories per gram	10689
B. t. u. per pound	19240
Water (per cent.)	Trace
Sulphur (per cent.)	0.18
Sand, etc.	None
Flash point (Pensky-Martens closed tester), below	—5° C.

Distillation.

Air distillation made with 5-inch column aluminum beads in modified Hempel flask.

Vacuum distillation in modified Hempel flask without beads.

Air distillation.

Temperature ° C.	Percentage by weight	Specific gravity at 15° C.	Pressure Mm. Hg.
Up to 100	6.9	.689	740
100-125	4.9	.747	740
125-150	4.6	.764	740
150-175	4.7	.778	740
175-200	4.0	.797	740
200-225	4.3	.809	740
225-250	4.4	.824	740
250-275	4.6	.833	740
275-300	6.3	.845	740

Vacuum distillation.

Temperature ° C.	Percentage by weight	Specific gravity at 15° C.	Pressure Mm. Hg.
Up to 200	1.7	....	23
200-225	4.5	....	23
225-250	7.3	....	23
250-275	1.3	....	23
275-300	5.0	....	23

Total distillates..........64.6%

Residue..........30.4%

Vacuum fractions contain paraffin wax solid at O° C.

Remarks: Sample can when received was not soldered and was leaking badly.

CONDITIONS OF ACCUMULATION.

From what has been said in discussing the geological structure of the region it may be seen that the conditions under which the oil has accumulated are not yet fully known. From our general knowledge of the structure, it is believed that the oil has not accumulated in a synclinal trough, as it often does where water does not saturate the rocks.

There is no evidence of a pronounced anticline or dome, though it is possible that a reversal of dip may occur west of the West No. 1 well. The writer is inclined to believe that the oil accumulation is due to a local flattening of the rocks, with some reversal of dips from the Toomey No. 2 for some distance to the east, forming a terrace or low anticlinal roll that interrupts the steady general westward rise of the rocks that is the dominant structural feature of the region.

An alternative hypothesis is that the rocks to the east may be or may have recently been saturated with water and that the oil has taken its present position in the rocks as a result of the pressure or buoyant effect and movement induced by the water. If so the oil should occur in a horizontal belt that will lie across the rising rocks like a contour line.

Or again, the oil may simply fill porous or fractured and fissured spaces in the Newman limestone without strict regard to either general structural or underground water-level conditions, but its occurrence may be dependent primarily on the presence or absence of such spaces in the rocks.

By keeping careful records of future wells much needed light can undoubtedly be thrown on the underground structure and on the conditions under which oil has accumulated in the region and as a consequence much more intelligent prospecting will become possible and the chances of successful drilling corresponding increased.

TECHNOLOGY.

Drilling.—Derricks and rigs of standard type have been used in drilling some of the wells, while drilling machines have been used in others.

Cost.—It is understood that wells away from the railroad have been contracted for at about $1.65 per foot, while those on the railroad have been taken for $1.50, the driller to move and place his rig and build his derrick, which may afterward be removed by him, or provide his drilling machine, water, fuel and everything except casing.

Water may usually be had in the many small streams of the region except in late summer and autumn when most of them go dry. It may be reached by wells at slight depths anywhere. Coal is available in some places for drilling, and wood may be had in abundance everywhere.

The roads of the region are neither very good nor very bad. They probably average better than in most Appalachian oil regions. Labor may be had at reasonable prices.

LAND HOLDINGS.

Much of the area has been bought in years past for coal and timber and is held in tracts of from 5,000 or 10,000 to 40,000 or 50,000 acres. The owners of a number of these tracts are pursuing a liberal policy in granting leases to parties who desire to develop their leases, but do not encourage leasing to be held for speculative purposes.

WARNING AGAINST IMPOSTORS.

Parties have been operating in the region who profess to be able to locate oil with a device that is supposed to "work" on some heretofore unheard-of electrical principle, when carried by the manipulator over an area where there is oil. It can not be too strongly emphasized that there is no known instrument or device that when carried over the surface may be made to "work" or vibrate or be affected in any manner whatsoever by oil deposits in the rocks beneath. All such claims are fraudulent, and money spent in hiring such "oil finders" is simply wasted, whether they operate with a witch hazel wand, a peach tree switch or a supposed electrical or other device.

Publications of Geological Survey of Tennessee Issued.

The following publications have been issued by the present Survey, and will be sent on request *when accompanied by the necessary postage.* Gaps in the series of numbers are of reports still in preparation:

Bulletin No. 1—Geological Work in Tennessee.

A. The establishment, purpose, object and methods of the State Geological Survey; by Geo. H. Ashley, 33 pages, issued July, 1910, postage, 2 cents.

B. Bibliography of Tennessee Geology and Related Subjects; by Elizabeth Cockrill, 119 pages; postage, 3 cents.

Bulletin No. 2—Preliminary Papers on the Mineral Resources of Tennessee, by Geo. H. Ashley and others.

A. Outline Introduction to the Mineral Resources of Tennessee, by Geo. H. Ashley, issued September 10, 1910; 65 pages; postage, 2 cents.

D. The Marbles of East Tennessee, by C. H. Gordon; issued May, 1911; 33 pages; postage, 2 cents.

E. Oil Development in Tennessee, by M. J. Munn; issued January, 1911; 46 pages; postage, 2 cents.

G. The Zinc Deposits of Tennessee, by S. W. Osgood; issued October, 1910; 16 pages; postage, 1 cent.

Bulletin No. 3—Drainage Reclamation in Tennessee; 74 pages; issued July, 1910; postage, 3 cents.

A. Drainage Problems in Tennessee, by Geo. H. Ashley; pages 1-15; postage, 1 cent.

B. Drainage of Rivers in Gibson County, Tennessee, by A. E. Morgan and S. H. McCrory; pages 17-43; postage, 1 cent.

C. The Drainage Law of Tennessee; pages 45-74; postage, 1 cent.

Bulletin No. 4—Administrative Report of the State Geologist, 1910; issued March, 1911; postage, 2 cents.

Bulletin No. 5—Clays of West Tennessee, by Wilbur A. Nelson; issued April, 1911; postage, 4 cents.

Bulletin No. 9—Economic Geology of the Dayton-Pikeville Region, by W. C. Phalen, for sale only, price 15 cents.

Bulletin No. 10—Studies of the Forests of Tennessee.

A. An Investigation of the Forest Conditions in Tennessee, by R. Clifford Hall; issued April, 1911; 56 pages; postage 3 cents.

B. Chestnut in Tennessee, by W. W. Ashe, issued December, 1911; postage, 2 cents.

C. Yellow Poplar in Tennessee, by W. W. Ashe, issued January, 1914; 55 pages; postage, 3 cents.

Bulletin No. 13—A Brief Summary of the Resources of Tennessee, by Geo. H. Ashley; issued May, 1911; 40 pages; postage, 2 cents.

Bulletin No. 14—The Zinc Deposits of Northeastern Tennessee, by A. H. Purdue; issued September, 1912; 69 pages; 30 illustrations, postage, 3 cents a number.

Bulletin No. 15—Administrative Report of State Geologist, 1912.

Bulletin No. 16—The Red Iron Ores of East Tennessee, by E. F. Burchard; issued November, 1913; 172 pages; postage, 8 cents.

Bulletin No. 17—The Water Powers of Tennessee, by J. A. Switzer; issued April, 1914; 137 pages; postage, 8 cents.

Bulletin No. 18—Administrative Report of the State Geologist, 1914.

"THE RESOURCES OF TENNESSEE."—This is a quarterly magazine, devoted to the description, conservation and development of the State's resources. Postage, 2c a number. The following are the volumes and numbers issued, with the titles of the principal papers in each number:

Vol. I. No. 1—The utilization of the small water powers in Tennessee, by J. A. Switzer and Geo. H. Ashley.

No. 2.—The Camden chert—an ideal road material, by Geo. H. Ashley.
The Fernvale iron ore deposit of Davidson County, by Wilbur A. Nelson.
Cement materials in Tennessee, by C. H. Gordon.

No. 3—The gold field of Coker Creek, by Geo. H. Ashley.

No. 4—Coal resources of Dayton-Pikeville area, by W. C. Phalen.

No. 5—Economic aspects of the smoke nuisance, by J. A. Switzer.
Watauga Power Company's hydro-electric development, by Francis R. Weller.
The coal fields of Tennessee, by Geo. H. Ashley.

No. 6—Bauxite Mining in Tennessee, by Geo. H. Ashley.
A New Manganese Deposit in Tennessee, by Wilbur A. Nelson.
Road Improvement in Tennessee, by Geo. H. Ashley.

Vol. II. No. 1—The Utilization of the Navigable Rivers of Tennessee, by Geo. H. Ashley.
Dust Explosions in Mines, by Geo. H. Ashley.
The Rejuvenation of Wornout Soil Without Artificial Fertilizers, by Geo. H. Ashley.
Tennessee to Have Another Great Water Power, by George Byrne.
Manufacture of Sulphuric Acid in Tennessee in 1911, by Wilbur A. Nelson.

No. 2—The Ocoee River Power Development, by J. A. Switzer.
Exploration for Natural Gas and Oil at Memphis, Tenn., by M. J. Munn.

No. 3—The Power Development at Hale's Bar, by J. A. Switzer,
Notes on Lead in Tennessee, by Wilbur A. Nelson.

No. 4—The Tennessee Academy of Science.
The Preliminary Consideration of Water Power Projects, by J. A. Switzer.
Lignite and Lignitic Clay in West Tennessee, by Wilbur A. Nelson.

No. 5—The Growth of Our Knowledge of Tennessee Geology, L. C. Glenn.

No. 6—On the Impounding of Waters to Prevent Floods, by A. H. Purdue.
Drainage Problems of Wolf, Hatchie, and South Fork of Forked Deer Rivers, in West Tennessee, by L. L. Hidinger and Arthur E. Morgan.
The Waste From Hillside Wash, by A. H. Purdue.

No. 7—Where May Oil and Gas Be Found in Tennessee? By Geo. H. Ashley.
Spring Creek Oil Field, by M. J. Munn.

No. 8—The Monteagle Wonder Cave, by Wilbur A. Nelson.
Cave Marble (Cave Onyx) in Tennessee, by C. H. Gordon.

No. 9—The Valley and Mountain Iron Ores of East Tennessee, by Royal P. Jarvis.

No. 10—The Iron Industry of Lawrence and Wayne Counties, by A. H. Purdue.
Some Building Sands of Tennessee, by Wilbur A. Nelson.

No. 11—Tests on the Clays of Henry County, by F. A. Kirkpatrick. Introduction, by Wilbur A. Nelson.
Barite Deposits in the Sweetwater District, by Herbert B. Henegar.

No. 12—The Soils and Agricultural Resources of Robertson County, by Reese F. Rogers.
The Iron Ore Deposits in the Tuckahoe District, by C. H. Gordon and R. P. Jarvis.

Vol. III. No. 1—The General Features of the Tennessee Coal Field North of the Tennessee Central Railroad, by L. C. Glenn.
The Tennessee Coal Field South of the Tennessee Central Railroad, by Wilbur A. Nelson.

Vol. III. No. 2—State Supervision of Forestry, by L .C. Glenn.
Conservation of the Water Powers of Tennessee, by J. A. Switzer.
Water Supplies for Cities and Towns, by A. H. Purdue,
Types of Iron Ore Deposits in Tennessee, by C. H. Gordon.
The Causes and Nuisance of Smoke, by Wilbur A. Nelson.
Geology and Engineering, by A. H. Purdue.

Vol. III. No. 3—The Gullied Lands of West Tennessee, by A. H. Purdue.
White Rock Phosphate of Decatur County, Tennessee, by T. Poole Maynard.
Mineral Products Along the Tennessee Central Railroad, by Wilbur A. Nelson.
Relations of Water Supply to Health, by J. A. Switzer.

Vol. III. No. 4—Minerals of Tennessee, Their Nature, Uses, Occurrence and Literature, by A. H. Purdue.
Building Precautions Against Earthquake Disasters, by Olaf P. Jenkins.

Vol. IV. No. 1—Relation of Water Supply to Health, by J. A. Switzer.
Earthquakes in East Tennessee, by C. H. Gordon.
The State Geologist and Conservation, by A. H. Purdue.
A. Tripoli Deposit near Butler, Tenn., by L. C. Glenn.

No. 2—The Brown and Blue Phosphate Deposits of South-Central Tennessee, by J. S. Hook.
Discussion, Lucius P. Brown.
Bauxite in Tennessee, by A. H. Purdue.

No. 3—Economic Geology of the Waynesboro Quadrangle, by N. F. Drake.
Recent Water Power Development in Tennessee, by J. A. Switzer.
Two Natural Bridges in Tennessee, by Hugh D. Miser.
Road Materials of Tennessee, by A. H. Purdue.
Report on the Water Powers of Tennessee.

No. 4—The Need of a Soil Survey of Tennessee, by C. A. Mooers.
The Geology of Perry County and Vicinity, by Bruce Wade.
Indexes to Volumes III and IV.

Vol. V. No. 1—The Hydro-Electric System of Tennessee, by J. A. Switzer.
West Tennessee Gullied Lands and Their Reclamation, by R. S. Maddox.
The White Phosphates of Tennessee, by J. S. Hook.

No. 2—Physiographic Influences in the Development of Tennessee, by L. C. Glenn.
Care and Protection of Forests, by R. S. Maddox.
Two Natural Bridges of the Cumberland Mountains, by Wilbur A. Nelson.

No. 3—The Iron Ore Deposits of Lewis County, Tennessee, by Reese F. Rogers.

The supply of Vol. 1 No. 2, Vol. III No. 1, and Vol. V No. 1, is exhausted.

6

VOLUME VI NUMBER 1

THE RESOURCES OF TENNESSEE

Published by the State Geological Survey
NASHVILLE, TENNESSEE

JANUARY, 1916

State Geological Commission

GOV. TOM C. RYE, *Chairman*

DR. BROWN AYRES, *Secretary*
President, University of Tennessee

H. KNOX BRYSON
Commissioner of Agriculture

DR. J. H. KIRKLAND
Chancellor, Vanderbilt University

BISHOP A. W. KNIGHT
Vice-Chancellor, University of the South

R. A. SHIFLETT
Chief Mine Inspector

Geological Corps

A. H. PURDUE
State Geologist

OLAF P. JENKINS
Assistant Geologist

PAUL C. BOWERS
Chemist

J. A. SWITZER
Hydraulic Engineer

R. S. MADDOX
Forester

CONTENTS

Oil and Gas Conditions in the Central Basin of Tennessee......A. H. Purdue
Oil and Gas Conditions in the Reelfoot Lake District of Tennessee ....A. H. Purdue
An Interesting Case of Spontaneous Combustion............Paul C. Bowers
Sketch of the Work Done by the State Geological Survey in 1915.
Publications of the State Geological Survey.

A typical view of the Embayment area, West Tennessee.

Oil and Gas Conditions in the Central Basin of Tennessee*

By A. H. Purdue.

INTRODUCTION.

The public generally is interested in oil and gas, and almost every landowner quietly fosters the hope that one or both of these products may some time be found in the rocks covered by his holdings. Either, found in abundance, is a source of quick wealth, especially if it occurs within easy reach of the market. For this reason, anything that suggests oil or gas is likely to arouse more or less interest in the locality where it occurs, and may lead to unwise and expensive drilling.† Nor is it always necessary to have the "indications", as a reason for the foolish expenditure of large sums, for often wells are put down many hundred feet deep without any good reason for expecting that they will be anything more than dry holes.

To the last statement, many well drillers will reply that some of the richest oil and gas fields of the country have been discovered by men of their vocation, without the aid or advice of a geologist. This claim will be conceded by all who know anything of the history of oil and gas development. It will also be conceded that there are fields, some of them developed and some undeveloped, where the geologist could have been or can be of little or no assistance, especially in the early developments therein. The conditions are of such nature that the geologist is not able to form a reliable opinion as to whether the products occur within the area or not; or if he thinks they do occur within the area, he may not be able to point out the localities where it is worth while to drill, nor those where it would be useless to expend money.

---

*To make this article as trustworthy as possible, the author submitted the manuscript to Dr. L. C. Glenn, Professor of Geology, in Vanderbilt University, who made valuable suggestions that were embodied in the paper.

†In wet places where the soil or rock contains a good deal of iron, a film of iron hydroxide is likely to form on the surface of small pools, and is often mistaken for oil. If such a film be pricked with a knife blade, it will break apart. A film of oil will not do this.

On the other hand, the geology of most parts of our country is so well known that the geologist, even in territory that has never been drilled, is able to tell where there is no chance for oil and gas, where there is a good chance for one or both, and where the chances though not first class, would justify drilling; and no one should undertake the expenditure of the large amount of money necessary to drill a prospective well, without the advice of a competent geologist. Only be sure that he *is* competent. Such a man will give good advice in regions where the surface criteria and his knowledge of the rocks beneath are such as to enable him to form an opinion. Where there are no surface criteria and he has no knowledge or but limited knowledge of the rocks beneath, he will frankly say so. It is then, and only then, that prospectors are justified in taking their own chances.

In connection with what was said about the lucky strikes of oil and gas without geological advice, it should be said that while the public hears a great deal of such, the knowledge of the dry holes so put down, neither travels far nor lasts long; and their number is many times greater than the successful wells. It is only fair here to state that not all wells located by geologists are successful, by any means. All that a competent geologist would claim would be the ability to designate the areas where there is little or no chance for the products, from those others where there is a possibility of finding them. In this way, he does his clients great service by saving them money that would be spent in hopeless territory, and in reducing their chances for loss by locating wells in the parts of the areas that give promise of responding to the drill.

CONDITIONS FOR OIL AND GAS.

In discussing the oil and gas conditions of the Central Basin, it might be more satisfactory to the reader, briefly to have given the general conditions under which oil and gas occur. These are well known among geologists, and may be stated as follows:

1. There must be a source for the oil and gas.
2. There must be a reservoir to contain them.

The source of oil and gas.—Concerning the origin of oil and gas, there are those who think they are formed by chemical reactions that take place within the earth, between different minerals; and those who think they are formed by reactions that take place as the result of organic matter in the rocks. Most geologists, perhaps all, use the latter as a working basis. That is to say, one of the first things they consider when a prospective new field is brought to their attention is whether or not any of the rocks beneath the surface ever contained a good supply of organic matter. If so, this fact, in so far as it goes, is encouraging. The organic matter was put down with the rock beds in which it occurs.

There are those who believe that oil and gas were formed from the remains of animals that lived in the sea at the time the beds were put down; and others who think that they were formed from the remains of plants that grew in the water where the beds were formed, and still others who think the plants were washed in by streams. Plant remains in beds now being formed beneath water have both sources, and doubtless have had ever since there were plants on the earth. The reasonable supposition is that both have contributed to the formation of oil and gas. Likewise, any given reservoir of oil and gas might have had an animal origin or a plant origin, or it might have come partly from the one source and partly from the other.

The reservoir.—It is plain that oil and gas can not accumulate, either in large or small amounts unless the rocks are capable of receiving and holding them. To receive them, there must be cavities of some kind. These may be open spaces in coarse-grained rocks, or joints in fine-grained ones. The coarse-grained, porous rocks are usually sandstones or conglomerates, the former being composed of coarse grains of sand, and the latter at least largely, of gravel, cemented together. Rocks of this kind form the best reservoirs. As gas will move more freely than oil, a reservoir for gas may be in finer-grained rock than for oil. In the same way, a reservoir for very thin oil may be in finer-grained rocks than for thick oil. Sandstones and conglomerates are the common porous rocks, and so frequently are they the rocks from which oil and gas are delivered to the surface, that drillers in quest of these products are on the constant lookout for "oil sands"; but they call any rock that yields oil a "sand".

The fine-grained, or rather the close textured rocks that contain oil and gas, are limestones and shales. Water, like oil and gas, will flow through the coarse-grained sandstones and conglomerates, and many of these are the source of water supply. But if water in quantity is found in close textured limestone or in shale, it must come from joints. The same is true of oil and gas. Such rocks are not considered so desirable as sandstones, for reservoirs.

Oil and gas nearly always occur in stratified rocks, by which is meant those that are in layers or beds. Igneous rocks are not in well defined layers and but few are known to contain oil and gas. The best conditions in rocks saturated with water, occur where the rock beds are bowed upward, forming anticlines. Where the rocks are dry, the oil tends to move down any possible slope and accumulate in the troughs or synclines. Hence in regions of saturated rocks, the anticlines are sought by experienced oil men, while in regions of dry rocks, synclines are sought. Since it is more common to find the rocks saturated than dry, attention is mainly directed to the anticlines.

Another essential for a reservoir is that the open rock be covered with a "tight" or close textured one, so as to seal the oil and gas in. Without such a covering, these elusive products will escape upward and be scattered through the overlying rocks in inappreciable amounts, or what is more probable in the case of gas, will be given off into the air above.

It seems not improbable that nearly all stratified rocks originally contained organic matter that has produced more or less gas or oil, but if so, most of these have given up their products by dispersion to other rocks and to the atmosphere, from want of adequate sealing-in conditions. In the case of oil under such conditions, much of the gaseous matter has escaped from it, leaving asphalt and its kindred products, such as albertite, ozokerite, grahamite, and gilsonite.

Yet another condition usually given as an essential for a reservoir, is that the open rock be underlain by a tight layer, like the overlying one, for the reason that oil or gas may be dissipated downward as well as upward.

Size of the reservoir.—The size of the reservoirs in which oil and gas are stored may not be larger than a pea, or it may cover many square miles. Examples of the small ones may be found in many limestones, in which occur cavities filled or partly filled with petroleum. Such limestones are seductive, for they excite prospecting, but seldom yield oil in paying quantity. The cavities may be numerous and all may contain some oil, but they are not connected, and consequently there is no possibility of the oil flowing from one to another and finally into the drill hole, from which it can be pumped to the surface.

Most of the large reservoirs are in sandstone, the storage space being composed of the infinite number of pores between the sand grains composing the rock. In fact each one of these small pores is a reservoir in itself, but they are all connected, and because of this the oil or gas will flow through the rock a limited distance to a drill hole. The actual distance through which it will flow varies, being short for small pores and low rock pressure, and comparatively great for large pores and high pressure.

Shape of the reservoir.—Where folding is a factor in forming the reservoir, its shape depends upon that of the structural features. If in an anticline, and the anticline be dome shaped the outline of the reservoir will be circular; but if the anticline should be of the common, elongated kind, the reservoir will be more or less linear in outline. For this reason, geologists and experienced well drillers work out the structure and follow it, not only in trying out an undeveloped field, but if the rocks prove to be saturated with water, in extending it after a successful well has been drilled.

But here the layman must be warned against making the common mistake of supposing that the bending of the rock layers conforms to the surface irregularities. The rock layers cannot be supposed to bow upward where there are hills and downward where there are valleys. If they are not level, they perhaps more commonly bow downward in the hills as synclines and upward beneath the valleys as anticlines; or more commonly yet, they dip in one direction as monoclines. In the latter case, the hard rock layers occur in the ridges, and the soft ones in the valleys.

Angle of the rock beds.—Folded rock beds may stand at any angle from near the horizontal to the perpendicular. The most desirable position for oil or gas is the one near the horizontal. This, for the reason that the lower the dip the wider the anticline and consequently the larger the field; and for the further reason that it is easier for the driller to put down a straight hole in rocks of low than of high dip. If the rocks dip as much as 20 degrees, it is difficult to drill a straight hole, especially if they consist of alternating beds of shale and sandstone or other hard rock. When the drill passes through a soft bed and strikes a high-dipping hard one, the tendency is for the bit to slip downward over the hard surface, and turn the hole away from the perpendicular. Yet, with care, an experienced driller can put down a straight hole in alternating beds of sandstone and shale that dip 20 degrees, or even more.

Horizontal reservoirs.—There are reservoirs that consist of lenses of sandstone lying horizontal or nearly so, sealed up in beds of shale. In such cases, neither the geologist nor the driller can locate the reservoir, without drilling. It follows that the striking of such reservoirs with the drill is a matter of chance; and after such a reservoir is struck, its size can be determined only by the driller.

THE CENTRAL BASIN.

It is for the double purpose of preventing further loss from what geologists believe is a hopeless quest for oil and gas in the Central Basin, by those who might in the future make the venture, as others have done in the past, and put down wells without geological advice; and for answering the question that frequently comes from those who are more cautious, as to whether oil and gas occur within the Central Basin, that this paper is written.

Enticements to prospecting—In the past, more or less interest has been aroused in many parts of the Central Basin over oil and natural gas. In places this has resulted in the expenditure of money by drilling wells from a few score to a few hundred feet deep, and in some cases several hundred feet deep. The stimulus to the sinking of the shallow wells has been the finding of small pockets of oil or gas, usually in drilling for water. When such are struck, the common belief is that by going deeper, a good supply would be found, but this has always resulted in disappointment. The conditions over the Central Basin are unfortunate for the reason that oil and gas are sufficiently common to entice people into spending money in their quest, yet they probably nowhere exist in paying quantities.

The reasoning followed by those who have backed the more pretentious searches by deep drilling, probably has been somewhat as follows: The striking of oil or gas is only a matter of luck anyway, and there is as good show for these here as anywhere. So we will take the chance. Or it may have been this way: Oil occurs in West Virginia and Pennsylvania. It also occurs in Louisiana, and we are on the line between the two. Therefore, oil should be found here. Without going into details, the writer wishes to say that neither of these supposed reasons are reasons at all, and no one should ever permit himself to be pursuaded to part with his money upon any drilling venture that has no more claim for merit than they contain.

Nature of the rocks.—The rocks that form the floor of the Central Basin are nearly all limestone. These rocks extend up a short distance above the floor around the edge of the Highland Rim and pass off in all directions beneath it. They are of Ordovician age, though this is of little interest to the prospector, except that a good portion of them belong to the Trenton division of the Ordovician. Many drillers still look with favor on rocks of Trenton age because these are the rocks that supplied the eastern Indiana and western Ohio field, which was in prominence 20 years ago. But it is one of the mistakes of drillers to suppose that Trenton rocks everywhere contain or are liable to contain, oil and gas.

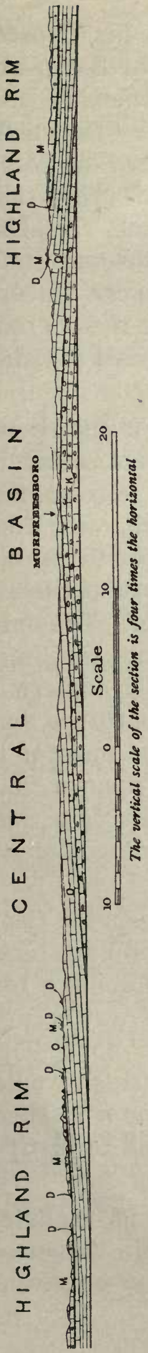
The formations composing the above mentioned limestones, named from the upper to the lower ones are Leipers, Catheys, Bigby, Hermitage, Carters, Lebanon, Ridley, Pierce and Murfreesboro. The maximum total thickness of these formations exceeds 800 feet. Below the Murfreesboro limestone, but not exposed anywhere within the Central Basin, is a formation called the Knox dolomite. This formation extends eastward beneath the Cumberland Plateau and is the surface rock in a large part of the Valley of East Tennessee, having received its name from Knox County. It is composed of limestone, dolomite, and a small amount of sandstone, and in East Tennessee reaches a thickness of 3500 feet. Its thickness in the Central Basin is not known, but that it occurs there is shown from its appearance in Wells Creek Basin 40 miles northwest of the Central Basin, in the southwestern part of Stewart County. It is not probable that the thickness of this formation in Middle Tennessee is as great as in East Tennessee.

With the exception of the Pierce formation, practically all the rocks of the Central Basin are limestone, and even this formation is itself composed of limestone and limey shale.

Structure of the Central Basin.—If the rocks of the Central Basin were level, only the upper formations of those named above would show at the surface; but instead, the Basin is a great arch, or rather a dome, of slight elevation. In general, the arching does not end where the rocks pass under the Highland Rim, but continues a greater or less distance beyond. The figure herewith will give a general idea of the structure.

The highest part of the dome occurs in the vicinity of Murfreesboro, Rutherford County; and here, all the upper formations have been removed down to the Ridley limestone, the Pierce shale, and the Murfreesboro limestone. This removal of the rocks is a part of the general one that has taken place all over the Central Basin, and to this the basin owes its existence. The process of removal has been mainly by solution. The Highland Rim has escaped removal, because the rocks composing it are more siliceous than those of the Central Basin and for this reason have resisted the solution that took place in the comparatively easily soluble limestones of the latter area. The agent of solution was the water that fell as rain, and flowed off over the surface and through the rocks.

As the rock beds were arched up higher in the vicinity of Murfreesboro than elsewhere, it will be seen that the removal of the rocks from the area would bring the lower and older



Section showing the structure of the Central Basin.
K, Knox dolomite.
O, Ordovician limestones.
D, Devonian black shale.
M, rocks of Mississippian age (Ft. Payne chert and St. Louis limestone.)
The divisions of the scale indicate miles.

ones to the surface in that locality. The Ridley limestone and the Murfreesboro limestone are separated only by the Pierce shale, which is a thin formation, less than 30 feet thick, and like the other two, is in most places covered with soil. Where this is exposed it can easily be recognized, but the Ridley limestone and Murfreesboro limestone are so much alike that it is difficult for even the geologist to distinguish them except in places where they can both be seen, with the Pierce shale between them. In such places, it is known that the limestone above the shale is Ridley, and that below is Murfreesboro.

It must not be supposed that the rock beds dip off uniformly from the highest part of the arch, like the surface of a very flat dome. Rather, they are in small, wave-like folds, the beds here passing downward, forming troughs, and there upward, forming arches. From the somewhat limited investigation made by this survey, it appears that none of these folds are long, but die out in short distances and are succeeded by others, giving the whole structure a wobbly form.

Natural gas and oil conditions as applied to the Central Basin.—As above stated, the rocks of the Central Basin are nearly all limestone. Limestone is formed by the chemical precipitation of lime carbonate from sea water, and by the shells of animals that die in the sea. The large number of fossil shells found in the limestones of the Central Basin prove that they were formed at least in large part from animal remains. The probability is that the amount of such remains was sufficient to form a good supply of oil and gas. So we can reasonably conclude that the first condition for forming these products in commercial amount was supplied in the organic remains put down with the rock.

But when it comes to the other condition, that is the reservoir for containing the oil and gas, the prospect is not so favorable. It is true that the area itself is occupied by a great, flat arch, upon the sides of which are numerous small, wave-like folds. So far as this goes, the conditions are most favorable indeed. But the rocks, like most limestones, are close textured. There are no pores in which oil and gas may collect. The only receptacles for such are in the joints that penetrate the limestone beds. These, in places at least, are probably numerous enough to form gas reservoirs of considerable importance, but there is no fine-grained stratum to seal this in, and most of it has escaped into the air. The nearest approach to a cover that would retain the gas is in the Pierce shale, but this is a thin formation, and is itself too limey and too much jointed for an effective cover.

As above stated, there are numerous localities over the Central Basin where a small amount of gas and some oil have been sealed in, and these are not infrequently struck in drilling for water. But the oil is insignificant in amount where it occurs at all, and the gas usually exhausts after a few days' flow. The greatest supply of gas they could be expected to furnish would be for private use, such as heating a residence, or a kitchen range. In most cases, the supply would be too small to justify the necessary piping even for one of these purposes.

The question often comes up as to whether it would be advisable to go deeper in those wells of the Central Basin that produce gas. To this question, no general answer can be given.

Whether or not deeper drilling would be advised in order to get a supply of gas for household use would depend in each case upon the location of the well. In some wells, doubtless deeper drilling would result in an increased flow of gas, but in no case would it be thought advisable to drill very deep. It is the belief of the writer that such limited reservoirs of oil and gas as occur in the Central Basin will be found in those rocks that lie above the Knox dolomite. Possibly an appreciable amount of these products would be found in the upper part of that formation, but every foot of descent through it, decreases the prospect of finding any.

In the vicinity of Murfreesboro, where the arch stands highest, the Knox dolomite would be reached near the surface, and would be deeper the greater the distance from that area. This will be made plain by inspecting the figure on page 11. Its greatest depth would be found next to the Highland Rim. Where all the formations of the Basin occur above the Knox dolomite, its depth from the surface would be the aggregate thickness of those formations, which is approximately 800 feet.

Conclusion.—As the reader has gathered from the foregoing, it is the writer's belief that oil will nowhere be found in utilizable amount in the Central Basin, and that gas can not be expected in greater amount than a supply for private use. The most likely localities for such supply are in the outer parts of the area, and in the tops of the folds or wobbles that occur on the sides of the main arch.

OIL AND GAS WELLS.

It should be remembered that this paper is confined to the oil and gas conditions of the Central Basin. It does not include the surrounding Highland Rim, in which the oil and gas conditions are more or less different.

Besides the numerous shallow wells of the Central Basin that have produced a showing of oil and more or less gas, Mr. M. J. Munn has reported several deep ones.* In order to get the known facts of the area together, what Mr. Munn has to say about these wells is here reproduced. It will be seen that the results support the general belief among geologists who are familiar with the Central Basin that oil and gas do not occur there in commercial amounts. What Mr. Munn says about these wells is as follows:

---

*Preliminary report upon the oil and gas developments in Tennessee. Bull. 2-E, Tennessee Geological Survey, pp. 29-31.

Lincoln County.—While Lincoln County is embraced by the Highlands, much of its surface consists of large valleys and lowlands where the outcropping rocks are of the same age as those of the Central Basin.

Five wells have been put down in this county in search of oil and gas or for large supplies of water. One of these was located near an old oil spring south of Argyle in the southwestern part of the county. Another well was drilled still farther to the southwest near Blanche. Both of these wells are reported to have found a small amount of oil, but details regarding them could not be secured. In the northwestern part of the county near Petersburg a well was started in search of oil on the Brown property in 1900 or 1901, but, after getting a "show" of oil, a string of tools was lost in the well at a depth of about 1,000 feet, and the hole abandoned. A considerable flow of gas with salt water was found at about 800 feet in a well drilled at Fayetteville to supply water for the city. This gas was not utilized, though it is said to have occurred in sufficient quantities to have been of commercial value if the well had been properly handled. A well drilled for water on the farm of Mr. Richard Smith at Smithland found sufficient gas at a shallow depth to be utilized by him for household purposes. Aside from the above wells a large number of shallow ones, drilled for water over the county, have shown more or less oil, gas and some salt water, but to date wells are too few to furnish reliable data regarding the possibility of oil and gas pools of commercial size being found in this region.

Giles County.—A deep well drilled in search of water in Pulaski is said to have reached a depth of 2,200 feet, in which small "shows" of both oil and gas were found. No other deep wells are known to have been drilled in this county, though numerous surface indications of both oil and gas occur.

Marshall County.—All but the southern portion of Marshall County lies within the Central Basin. In this county a few miles northwest of Lewisburg a well was drilled on the G. O. McRody farm for oil, about the year 1900. This is said to have reached a depth of 982 feet and to have furnished some gas. Near Ostella, in the southern part of the county, a water well drilled about 25 years ago on the John Bradford farm furnished considerable gas. South of Lewisburg in the vicinity of Yell and Cornersville many wells drilled for fresh water have supplied small quantities of oil, gas, salt water and sulphur water. One of these wells on the F. M. Parks farm is said to have furnished sufficient gas at a depth of 170 to 190 feet to burn in a flame from 10 to 20 feet high from the mouth of the well.

Maury County.—No deep wells have been drilled for oil and gas in this county. A shallow well sunk for water near Lovettsville in the eastern part of the county on the W. A. Jackson farm found gas at 90 feet in such quantities as to burn for several years from 20 to 25 feet above the well mouth. Other shallow wells at several places in this county have furnished small quantities of oil, gas and salt water. There are also many oil and gas springs, one of which is located under the river bluff at Columbia, where a constant, though small, supply of oil seeps from the Lebanon limestone.

Bedford County.—The first well drilled for the purpose of testing for oil and gas in this county was put down in 1886 or 1887 at Shelbyville, the county seat. It was drilled by a local company on a lot owned by Mr. B. R. Whitthorne and reached a total depth of 1,000 feet. The hole was 8 inches in diameter down to 363 feet, the remainder being 5 inches. Fresh water was encountered at several places in the 8-inch hole and brackish and mineral water at greater depths. Few indications of oil and gas were encountered, and the hole was plugged at 363 feet. In 1908 this well was cleaned out, pumping machinery installed, and the water from the 8-inch hole has since been utilized by the railroad company and for ice making. In 1902 or 1903 a well was drilled on the Swiver property, about 2 miles north of Wartrace, on the dirt road to Bellbuckle. This well is reported to have been drilled to a depth of 1,800 to 2,000 feet, but no data relative to it could be obtained. In 1904 or 1905 a well was also drilled for oil on the Matthew Skeen farm, about 1 mile north of Bellbuckle. This well is said to have been put down to a depth of 1,500 feet, but nothing is known of the results obtained. In 1906 or 1907 a well was drilled on the Zach Crouch farm, about 3 miles east of Bellbuckle, by the Wimber Oil Development Company. This well is said to have furnished no oil or gas. Many surface indications of oil and gas occur throughout this county. These consist of small seepages of oil from the limestone at many places and of local deposits of gas or small quantity encountered in shallow wells drilled for water. Several such indications have been found near Shelbyville and a noted oil seepage exists in the bluff of Duck River, south of this town. These indications led to the drilling of the deep well at Shelbyville. Considerable land is now under lease in this county for oil and gas.

Rutherford County.—As many as five wells have been drilled in this county in search of oil and gas but without finding either in commercial quantities. Several shallow wells drilled for water in the vicinity of Murfreesboro at various times since the Civil War furnished good indications of gas. One of these wells, on the Overall property, about 1 mile west of town, contained sufficient gas to cause the owner to attempt to utilize it for heating and lighting his residence. The gas, however, was repeatedly shut off by invasions of fresh water, and the attempt was for this reason, a failure. These indications led to the drilling of three wells near Murfreesboro. The first of these was on the House property, about 3 miles northwest of the town; the second on the E. W. Talley farm, about 7 miles from Murfreesboro and about 2 or 3 miles southward from Florence; the third well about 3 miles southwest of Murfreesboro on the W. B. Cooper farm. This well is said to have reached a depth of more than 1,000 feet, much trouble being experienced in getting the hole down. It is said to have flowed water from near the bottom. None of the wells is said to have furnished more than good shows of oil and gas. Two deep wells have also been drilled in the extreme southern part of the county near Fosterville on the J. G. Miller and B. F. Ransom farms. In the last named well the indications for oil are said to have been very favorable, but no information regarding depth to, and amount of, oil obtained is available. Several areas of considerable extent in this county are now under lease, but no drilling operations are being conducted at present.

Wilson County.—Although several large blocks of leases have been taken by oil and gas companies in this county since 1896, the drilling has been confined to a single well put down by the Union Oil & Development Company of Baltimore, Maryland, on the Chambers property near Moxie, about 5 miles north of Lebanon. This well is said to have reached a depth of about 1,000 feet without finding oil or gas.

Cannon County.—In this county near Woodbury a well was drilled several years ago by the South Penn Oil Company on the McFerrin property. It reached a depth of about 1,700 feet without finding oil or gas. Large quantities of Blue Lick water are said to have been found between 1,000 and 1,700 feet from the surface. Another well on the Samuel Banks farm was drilled to a depth of 600 to 800 feet in search of water. It is said to have furnished gas of sufficient pressure to blow the heavy drilling tools from the well. No other deep holes are known to have been drilled in this county.

Smith County.—This county lies in the northeastern part of the Central Basin, and so far as known but two wells have been drilled for oil within its borders. The first well was drilled shortly after the Civil War on the McMurray property, in the extreme northwestern portion of the county near Dixon Springs. This well is said to have reached a depth of several hundred feet and to have furnished "shows" of oil. In 1896 a well was drilled by the South Penn Oil Company on the T. J. Fisher farm, a short distance northwest of Carthage, the county seat. This well reached a depth of 900 feet, finding water at 235, 255 and 400 feet from the surface. An imperfect record of this well gives a thickness of 888 feet of limestone, no mention being made of shows of oil or gas. Numerous oil and gas springs occur in this region, especially in the vicinity of New Middleton, in the southwestern portion of the county, where it is said that many shallow wells drilled for water contain small quantities of oil and gas and much salt water.

Davidson County.—The writer was unable to secure any definite information relative to deep wells drilled in this county, though it is very probable that several tests have been put down for oil and gas. Shows of oil and gas in wells drilled for water have been found at many places in the limestones of the Central Basin and a number occur in Davidson County, but no pools of commercial size have yet been found.

Oil and Gas Conditions in the Reelfoot Lake District of Tennessee*

By A. H. Purdue.

INTRODUCTION.

Within the past year, a good many inquiries have come to this Survey about oil and gas conditions in the Reelfoot Lake area, and in quest of oil one well has been put down near the east shore of the lake, a short distance south of Samburg. At least one other company has been formed for the purpose of drilling, but at this writing they have not begun operations. The general search for oil and gas will continue for many years to come, and further inquiries are sure to be made about the possibility of finding these products within the area under consideration. This fact supplies the reason for this paper. Also, the question sometimes comes as to the general oil and gas conditions in West Tennessee, and in search of these products some wells were in recent years put down near Memphis. These have been reported on by Ashley and Munn.† This paper supplements the information given by those authors, for the reason that oil and gas conditions in the Reelfoot district can not be intelligently discussed without more or less attention to those of the Embayment area in general.

REASONS WHY THE REELFOOT LAKE AREA HAS ATTRACTED PROSPECTORS.

In stating the reasons why the Reelfoot area has attracted the attention of prospectors, it must not be understood that the writer is giving them his indorsement. It appears that three things have brought the attention of oil and gas men to this area. Probably the most important consideration that aroused an active interest in the area is that it is in the center of the well known series of earthquakes that occurred in 1811-12.

---

*For a good understanding of this article, the layman should read that part of the preceding one that relates to the conditions for the occurrence of oil and gas.

†Ashley, Geo. H., Tenn. Geol. Survey, Bull. 2-E, pp. 40-46; and Munn, M. J., *Res. of Tenn.*, Vol. II, No. 2, pp. 42-68.

Another thing that directed attention to this area as a possible oil and gas producer, is its surface resemblance to the Louisiana oil and gas field; but as similar surface conditions obtain along the Mississippi River from Cairo to the gulf, this fact probably was not so influential as the one already given.

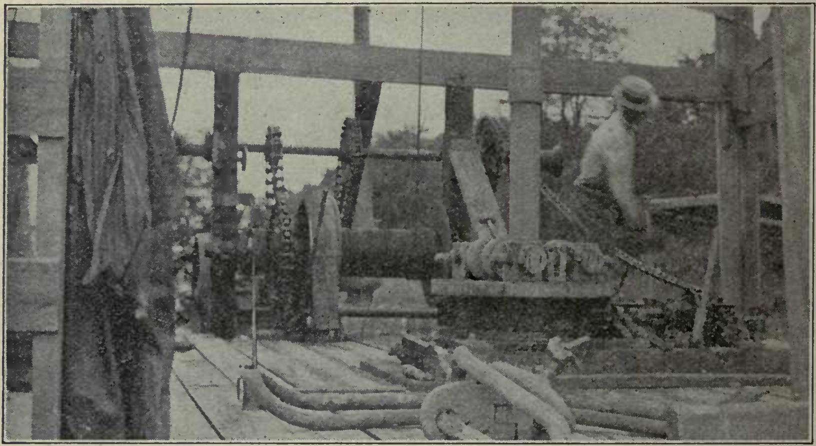


FIG 1. Rotary drill, operating at Reelfoot Lake. (A. H. P.)

A third thing that excited prospecting is the alleged existence of springs around the borders of the lake, that are said to produce some oil and gas.

THE REASONS CONSIDERED.

The reason of an earthquake center.—The reason why those interested in prospecting the area connect the possible occurrence of oil and gas with the earthquake of 1811-12, and subsequent ones of minor importance, does not seem to be well defined. Whether or not the probable occurrence of oil and gas here can be deduced from the changes that took place during those disturbances might be, at least in part answered, by noting just what ones did take place.

It is established by the writings of numerous men of high standing, as well as handed down by tradition, that during this series of earthquakes, numerous changes took place in this area and in near-by portions of Arkansas and Missouri. These changes consisted mainly in the subsidence of certain parts, converting them from a condition of more or less dry land to lakes.

The area of Reelfoot Lake, approximately 25 miles long, with a probable average of five miles in width, was previous to the earthquake, one of low land probably containing a good many old sloughs, and certainly one or more streams. Without the witnesses of tradition and literature, that of dead trees yet standing in the lake is convincing proof that the area recently has been submerged. The submergence could have come about either by sinking or by an elevation of the land immediately to the south, thus ponding the water; but if there was any such elevation it was not great enough to have formed the lake; besides the stream flowing out of the lake to the south would probably by this time have cut its bed down through the soft material over which it flows, and thus drained most of the area. So we must conclude that sinking took place.

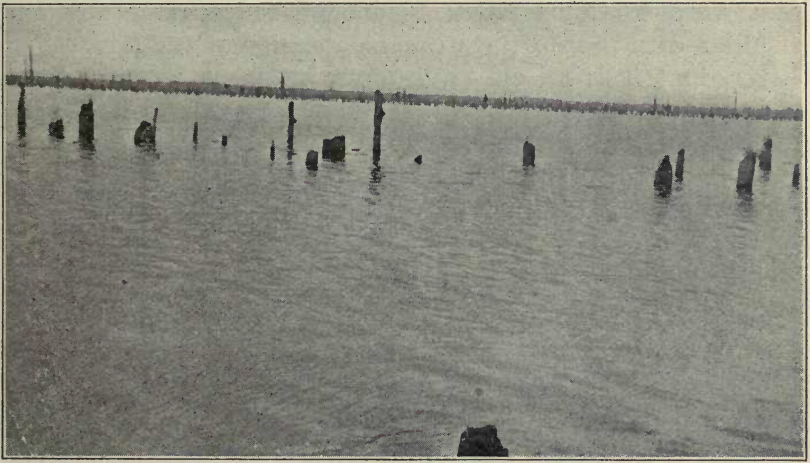


FIG. 2. Dead cypress trees in Reelfoot Lake. (A. H. P.)

Along the eastern border of the lake, there is a bluff more than 100 feet high, composed of soft beds of Tertiary age at the bottom, and a deposit of fine sand and clay at the top, known as loess, with a thin layer of gravel between the two. This bluff extends northward to Hickman, Kentucky, where it runs into and becomes a part of the bluffs of the Mississippi, and southward below Vicksburg, with the exception of breaks by such streams as Obion River, Forked Deer River, Hatchie River, Wolf River and others entering the Mississippi River from the east. This bluff is in places the present bank of the Mississippi River, as at Memphis, and in others a former bank, as east of Reelfoot Lake. A look at it from Hickman southward to Obion River, is enough to convince any one familiar with the shifting from side to side of the Mississippi River, that it is an old river bluff, and that Reelfoot Lake occupies a former river bed. The bluff is in no way due to the earthquake, as some interested in prospecting the area have supposed. The earthquake affected it, as may yet be seen, by forming fissures and terraces of limited extent on its surface. Such of these as the writer has seen are in the nature of landslides, and do not represent true fissureing.

Conclusive evidence that the site of Reelfoot Lake is a former river course may also be seen by one who has observed land surfaces in areas of shifting streams, in the gradual slope from the rich level, alluvial plain west of the lake, to the water's edge. This is plainly to be seen from a point east of Tiptonville, southward to the end of the lake.

That the site of the lake was an old river course, and was low land before the earthquake, is stressed for the purpose of eliminating the notion held by many that there was excessive sinking in this area, caused by the earthquake. It was an area, like all young river bottoms of flood-plain origin, made up of low ridges with intervening troughs, some of the latter filled with water a part or all the time, the whole having been drained by a stream of considerable size and probably several tributaries. It appears that this stream was called Reelfoot Creek before the earthquake, and it was this that gave the name to the lake.

With the picture before us of a wide bottom area, composed of low ridges and sloughs, it will be seen that sinking of only a few feet was necessary to form the lake. The writer has not been over the lake extensively, but he has crossed its widest part along two lines, and his conclusion, judging from the present depth of the water, the dead trees yet standing in the water, and information gathered from those familiar with the lake, is that the sinking nowhere much exceeded 20 feet, and that the average probably was less than half that amount. The statement sometimes heard, that the tops of trees may be seen barely projecting out of the water is not supported by the writer's observations nor the word of reliable men who have for years followed the business of fishing on the lake. The mulberry, one of the less common of the dead trees now standing in the water, is even yet occasionally cut to make posts of the trunk. All familiar with this tree know its trunk is short, and if enough stands above the water for a post, not much can be left beneath the surface. To be sure the mulberry grew on the highest ridges of the bottoms, but these were not far above the sloughs.

A flat-topped, circular Indian mound on the west edge of Chocktaw Island, west of Samburg, is somewhat more than 100 feet in diameter and stands approximately 8 feet above the water. As these mounds are never very high, the sinking could not have been excessive at this point. Off the shore of the island, the dead cypress trees are said by those familiar with the water to stand 16 feet beneath the surface. They also report that this is one of the deepest parts of the lake. Not allowing for filling, this would make the top of the mound 24 feet above the slough in which the cypress trees grew. Other Indian mounds are reported in the lake. That they were built here is in keeping with the custom of the Indians of the Ohio and Mississippi rivers, along which many mounds are found in swampy places.

Incidentally, it might be said that the growth of timber over the sunken part was luxuriant, as is shown by the number and size of the dead cypress trees still standing in the water. These will number from 4 to 10 to the acre, the largest ones being as much as 3 feet in diameter. Much of the smaller cypress timber and nearly all of other kinds have rotted off at the water surface, and fallen.

Tradition has it that the area between Reelfoot Lake and the river was elevated during the earthquake. The investigations of Mr. M. L. Fuller* and others establish the existence of a dome extending from "the vicinity of New Madrid southward to the vicinity of Caruthersville, a distance of 15 miles, and from a point west of the Mississippi to Reelfoot Lake, a distance of 5 to 8 miles." Mr. Fuller states that some of the doming was almost certainly due to the earthquake of 1811, but says that if Little Prairie, on which New Madrid is situated is a part of the dome, the uplift will have to be referred to an earlier date, as New Madrid village previous to the shock was on high land, never covered by the floods.

It is the present writer's belief that if any doming took place in 1811, it was very slight indeed, for the level alluvial plain on which Tiptonville stands is now probably not more than 6 to 8 feet above the level of the lake. It must have had approximately this elevation before the earthquake, for it is said to have been timbered with oak, ash, sycamore, sweet gum, and other trees that thrive in land that is fairly well drained. The timber of the lake area was chiefly cypress, which proves a low, swampy condition before the earthquake.

As further evidence of a comparatively high elevation of the land west of the lake before 1811, it is stated by the present residents that some of the land about the present site of Tiptonville was then cleared and in cultivation.

The probable existence of this dome before the earthquake makes it much more inviting as a possible source of oil and gas than if it had been formed during that time, for the reason that the deep-seated agencies that caused it affected all the deposits of the area, down to the old rock floor. These deposits are described later in the paper. The effects of the earthquake were largely if not wholly superficial. Also, the accumulation of oil and gas is such a slow process that the time since 1811 is too short for any considerable store of either to have been formed.

---

*U. S. Geol. Surv., Bull. 494, p. 63.

What has been said is in the attempt to make it clear that there is little or no connection between the earthquake and its results and the possible occurrence of oil and gas. The sinking was nowhere very great and it is the writer's belief that the material affected did not reach far beneath the surface. It was a superficial phenomenon, due mainly to the soft, mucky nature of the material of the old abandoned river course, but possibly in part to the soft Tertiary deposits immediately beneath, that were saturated with water. That this is true is shown by the sinking having been confined to the old river course. The area was underlain by muck and water-filled sand and the low ridges were in a sense floating islands, on this material. The writer believes that the sinking took place by the settling of the material under the influence of the shake, by the squeezing out of the muck into the sloughs and stream channels and as mud spouts here and there over the surface, and by forcing water from the saturated sand lenses to the surface. Certainly, the sinking was one of the results of the earthquake, and not a cause.*

Even if it be granted that the phenomenon was a deep-seated one, this would be unfavorable to the presence of oil and gas in the immediate vicinity of the lake. For the fissuring of the material down to great depths probably would have left rents from which they, especially the gas, could escape.

Resemblance to the Louisiana field.—There is a general resemblance between the Reelfoot Lake area and the Caddo oil and gas field of Louisiana, in that they are both low and poorly drained, and both contain shallow lakes. But these are superficial matters that have no bearing on the occurrence of oil and gas. The land of the Reelfoot Lake area is low because it, in common with the region from the bluffs on its eastern margin, westward to Crowleys Ridge in Arkansas, is one of river erosion. There is no more reason to expect a successful oil well on the border of the lake than at Dyersburg or Union City or

---

*This discussion refers only to the Reelfoot Lake district; but from what the writer has seen of the "sunk lands" in northeast Arkansas he thinks the same explanation of origin will in general apply to them. For a full discussion of the New Madrid earthquake, see Shepard, E. M., *Journal of Geology,* Vol. XIII, pp. 45-62. Also Fuller, M. L., U. S. Geol. Surv., Bull. 494.

any other point between. For after the drill passed through the material of the bluff, and on down past the level of the old river bed, as far as anybody can now tell, the same strata would be penetrated and the same conditions encountered at any of the latter places as immediately about the lake.

As for the surface resemblance of the two areas, that counts for nothing; but there is a similarity of geological conditions that is worth attention. This is brought out below, in discussing the geology of the Embayment area.

Oil and gas springs.—As above stated, the writer has not seen any of these reported springs, but concerning the occurrence of oil in them, he is exceedingly skeptical. What is thought to be oil, more likely is a film of iron hydroxide, which is not uncommonly seen on the surface of small pools of water in boggy places, and which is frequently mistaken for oil.

These springs probably are not deep-seated. More likely they receive their supply from the water of the land that stands above the lake shore. This is true of the few springs that the writer has seen along the east margin of the lake, the water of which comes from the material of the bluffs. Such springs as issue down near the edge of the lake would be expected to contain more or less marsh gas, derived from the decay of the organic matter buried in the alluvial deposits bordering the water.

GEOLOGY OF THE AREA.

A consideration of the possible occurrence of oil and gas within the area under consideration forces attention to its geology, and this in turn requires that the main facts in the geology of the Gulf states be reviewed.

The lowlands of the Gulf states, including western Tennessee and Kentucky and eastern Arkansas, lie in what is known as the Embayment area. The northern limit of this area reaches a short distance across the Ohio River in the vicinity of its mouth. The rocks of most land areas were put down beneath the sea and those of this one are no exception to the rule, if we do not include those within comparatively few feet of the top,* concerning the origin of which there is some doubt. However, the deposits of the Embayment area differ from those that surround it in being much younger and in consisting for the most part of soft, unconsolidated material, such as sand and clay. The youth of these deposits is due to their having been put down during comparatively recent invasions of the sea, at which times the Gulf lapped over upon the continent, each covering more or less of those parts of Tennessee, Arkansas and the other states above named, as lying within the Embayment area.

---

*The loess and the Lafayette formation.

There were several of these invasions of the Gulf. The first one covered the eastern part of Texas; reached up into southern Arkansas, and extended eastward well into Alabama, and at least as far as Wayne County in Tennessee. This was during what is commonly called Lower Cretaceous times, and the deposits put down in the seas of this time are accordingly of Lower Cretaceous age.† The northern extent of these deposits is not known, because in that direction they are covered by younger formations. In Arkansas and Texas they consist of beds of chalk, limestone, sand, clay and gravel. Where exposed in Hardin and Wayne counties, Tennessee, they consist of sand and gravel.

After the Lower Cretaceous beds were deposited, the Gulf retreated to the south, leaving the topmost of those beds forming a land area. The extent of the southward retreat of the shore line is not known. After a considerable lapse of time, it again advanced northward, this time reaching past the present site of Cairo, Ill. This was during what is commonly called Upper Cretaceous* time, and the deposits then put down are of Upper Cretaceous age. These deposits are in three formations, known as the Eutaw sand, the Selma clay, and the Ripley formation. They are important in this connection, for if oil or gas or both, occur in the Embayment area, they are more likely to come from some of these formations than from the younger ones above. They will have more attention later in this paper

After the deposition of these formations, the sea again withdrew to the south, leaving the younger of these rocks and possibly some of the edges of the older ones as a land area.

---

†This is also called the Comanchean period. *Geology,* by Thomas C. Chamberlin and Rollin D. Salisbury. Henry Holt and Company.

*Chamberlin and Salisbury call this the Cretaceous period.

After another considerable lapse of time, the sea again encroached upon the Embayment area. On the Arkansas side, it seems to have extended further west than it did during the Upper Cretaceous advance, and it reached equally as far north; but in Tennessee it perhaps did not reach so far east as did the Cretaceous sea. This was during Tertiary times. The invasion was much interrupted, the shore line having shifted back and forth over the area many times.* The deposits then put down are of Tertiary age. As a result of this shifting, the deposits are much complicated, and the several divisions are now known under as many different names, but for the sake of simplicity they will here be described under their old names, the Porters Creek and Lagrange formations. After the deposition of the younger of these formations, the sea again retreated, again leaving the area as dry land.

There are gravels and sands, generally known as the Lafayette formation, over more or less of the area, but the origin of these is in doubt. For this reason, and because this and a yet younger formation that occurs along the Mississippi River, known as loess, do not enter into the problem of oil and gas, they will not be considered further.

Cretaceous formations of Tennessee.—The Cretaceous deposits of the Embayment area are mainly of Upper Cretaceous age. They have been described by the late Dr. James M. Safford in the *Geology of Tennessee*, by Dr. L. C. Glenn**, by Dr. L. W. Stephenson,† and others. ‡

For the purpose of description, the lowest part of the Cretaceous deposits in Tennessee may be called the Eutaw sand, that being the name by which it has been known in recent years.§

---

*Berry, E. W., U. S. Geol. Surv., Prof. Paper, 95-F.

**U. S. Geol. Surv. Water Supply and Irrigation Paper, No. 164.

†U. S. Geol. Surv., Prof. Paper, No. 81.

‡Mr. Bruce Wade is making a careful study of these deposits for this Survey, but his work is not yet finished, and no part of his results have been published.

§The work lately done by Messrs. H. D. Miser and L. W. Stephenson of the U. S. Geological Survey and Mr. Bruce Wade of this Survey, indicates that the lower part of what is here called Eutaw sand, is Tuscaloosa, a formation well developed in Alabama, but less so in Tennessee. Its most conspicuous development in Tennessee is on the hills east of Tennessee River. It is considered of Lower Cretaceous age.

The formation consists largely of loose sand, but it is interbedded with lenses of clay. It was put down in shallow water that contained rather strong shifting currents, that here and there along the course of their greatest strength, scoured out the bottom. The troughs thus formed were soon filled up by other sand and clay, the result being irregular deposition—a prominent character of the formation.

While lenses of clay enter rather largely into the composition of this formation, its character as a whole, where it is exposed, would not interfere with the free circulation of water or of oil, should it contain that product. It contains more or less brown-coal or lignitic material, and petrified wood. The thickness of the Eutaw formation in Tennessee is thought by Dr. L. C. Glenn to be from 250 to 275 feet.*

This formation shows at the surface in Tennessee only in parts of Benton, Decatur, Henderson, Hardin and McNairy counties. That it is continuous entirely across the Embayment area is indicated by its probable occurrence in southeastern Arkansas where it is known at the Bingen sand.† Its northward extent is more doubtful, as it is overlapped in that direction by younger deposits. It may reach nearly to the northern border of the Embayment area, and again it may fall far short of that.

The next formation above the Eutaw sand is the Selma clay. In Alabama and Mississippi this formation is known as the Selma chalk, but before reaching Tennessee it loses its chalky nature, and becomes a clay that in places contains large numbers of fossil shells. The clay is leaden gray, green, or blue, depending partly upon whether it is wet or dry or unaffected by the weather, and partly upon its somewhat different composition in different parts. Its thickness in Tennessee, as given by Dr. Glenn, is from 100 to 275 feet.‡

This formation can be seen at the surface in Tennessee only in a belt from 6 to 8 miles wide, just west of the one where the Eutaw is exposed. Like that formation, it is covered to the west and north by younger formations, and like the Eutaw it probably covers the Embayment westward to southwestern Arkansas, where it is known as the Annona chalk.† It probably extends northward well toward the head of the Embayment.

---

*U. S. Geological Surv. Water Supply and Irrigation Paper, No. 164, p. 25.

†Unpublished tentative correlation table by L. W. Stephenson, U. S. Geol. Surv.

‡*Loc. cit.,* p. 26.

Unless this formation becomes more sandy in the middle of the Embayment than in the area where it outcrops in Tennessee, it could not be expected to contain oil or gas; but it would form a good cover to seal in such of these products as might occur in the Eutaw sand beneath.

The formation above the Selma clay is the Ripley‡ This is described by Dr. Glenn as bearing a close resemblance to the Eutaw sand, inasmuch as it is composed of sand containing beds of clay. The clay beds are reported by him as being 10 to 20 feet or more thick. Many of them contain lignite in small pieces or thin beds, and leaf remains are common.

This formation extends across Tennessee, entering the state from Mississippi on the south, and passing into Kentucky on the north. Dr. Glenn thinks it is probably 500 feet thick in the southern part of Tennessee and says it is reported to be 400 feet thick at Wickliffe, Ky. As it is composed largely of loose sand, it should form a good reservoir for oil or gas, at such points as the other conditions for those products obtain, if they obtain anywhere.

Tertiary formations.—As above stated, the sea withdrew from at least a large part of the Embayment area, after the Ripley formation, the last of the Cretaceous ones in Tennessee, was put down. The land thus formed remained such for a long period of time, during which it was partly removed by running water. After this land period, the sea again advanced, and put down upon the old surface, a deposit known as the Porters Creek formation. Dr. Glenn* says that "the formation is composed mainly of fine-grained clay that is very dark gray, or in places almost black, when wet, but which becomes a light gray on drying". He gives its thickness at Jackson, Tennessee, as about 175 feet, and considers this the best measurement available. This formation shows at the surface in Tennessee, in a belt from 4 to 8 miles wide, just west of the Ripley area. Paris and Huntingdon stand near the western border, and Henderson is on the line between this formation and the Ripley. Northward, it passes on into Kentucky, and southward into Mississippi.

---

†Correlation by L. W. Stephenson, U. S. Geol. Surv.

‡This recently has been redefined by Stephenson, U. S. Geological Survey, Professional Paper 81. Stephenson puts the lower part of the Ripley, as defined by Glenn (Water Supply and Irrigation Paper No. 164, p. 27), in the Eutaw and the upper part he calls the McNairy sand; but for convenience, Dr. Glenn's definition is here used.

**Loc. cit.*

The Porters Creek formation is covered by the Lagrange formation. According to Dr. Glenn's description, "The formation consists of interbedded sands, clays, and lignitic material. Much the larger part is sand, which is mostly fine-grained, though here and there throughout the formation beds of medium or coarse sand or even gravel may be found. Such coarse beds do not seem to be continuous over any large area".

Regarding its thickness, Dr. Glenn says, "In the deep well at Memphis, the Lagrange is 963 feet thick. The well at Dyersburg penetrated 678 feet of it and one at Hickman 750 feet without in either case reaching its base. In the Jackson well, near the top of the formation, its base was reached at a depth of 160 feet. At Wickliffe it is 430 feet thick and at Cairo 325 feet." It appears that the thickness of the formation, as shown in the Memphis well, may safely be relied upon for that part of the state near the Mississippi River.

If we disregard the loess, which, with the exception of the alluvial bottoms, covers an area about 30 miles wide east of the Mississippi River, and the thin surface mantle known as the Lafayette formation, the Lagrange formation covers the surface of all that part of Tennessee west of the Porters Creek; and like the Porters Creek and Ripley, it extends northward into Kentucky and southward across Mississippi.

AGGREGATE THICKNESS OF THE WEST TENNESSEE EMBAYMENT FORMATIONS.

Taking the thickness of the Eutaw sand as 275 feet; of the Selma clay as 375 feet; of the Ripley as 500 feet; of the Porters Creek as 175 feet; and of the Lagrange as 963 feet, the total thickness below the Lafayette is 2288 feet. This estimate, of course, applies to those areas where all the formations occur, as they quite certainly do in southwestern Tennessee, and as is indicated in the Reelfoot Lake area, by the depth of the well south of Samburg. If wells should be put down on or a short distance east of the bluffs of the Mississippi, there should be added to this, perhaps 10 feet for the Lafayette and on an average of 50 feet for the loess, making a total thickness of approximately 2348 feet. One of the wells at Memphis was sunk 2517 feet without reaching the old rock floor, which indicates, as elsewhere mentioned in this paper, a thickening of the Cretaceous in the middle of the Embayment.

STRUCTURE OF THE AREA.

As will be seen by reading the preceding article in this number of the *Resources*, the occurrence of oil or gas in any area depends largely upon the structure, or the lay of the formations occurring beneath the surface; and as the Reelfoot Lake district is a part of the Embayment area, its structure can be understood only when taken in connection with that of the whole area.

In Tennessee, the general dip of the formations described above is to the west. According to the observations of Dr. Glenn* this does not much exceed 20 feet to the mile. In Kentucky, the dip swings around to the southwest, in Illinois to the south, and in Missouri and Arkansas to the southeast and east. It will thus be seen that the formations of the Embayment area lie as a wide trough, the sides of which slope in a general way toward the Mississippi, though the lowest part of the trough may not be on the present line of the river; and that the Reelfoot district, situated as it is near the head of the Embayment area, is in the focus of the southwest, south, and southeast dips of that part of the Embayment area in Kentucky, Illinois and Missouri.

The above is the general structure in the Embayment area. As to smaller structural features, it will be recalled that since the early deposits of the area were formed, there have been

---

**Loc. cit.*

ERRATA
Fig. 3, page 31, should be inverted.

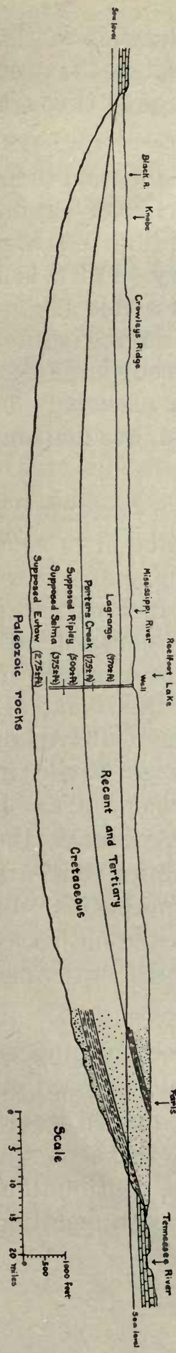


FIG. 3. East-west structural section, largely ideal, of the Embayment area, in the vicinity of Reelfoot Lake.

several recessions of the sea from the land. As above stated, one of these recessions took place at the close of the Lower Cretaceous, one at the close of the Upper Cretaceous, and several during the Tertiary. Between these, there were the corresponding advances of the sea upon the land. A retreat of the sea is usually taken to mean an elevation of the land, forcing the shore lines seaward. The other possibility is that the ocean bed may subside, causing the shore line to retreat, or the ocean bed may rise, causing the shore line to advance. Many of the geographic changes of the past certainly have been due to the one cause and probably some of them to the other. In the case of the Embayment area, the evidence is strongly in favor of at least the more important of geographic changes having been produced by elevations and subsidences of the area itself.

Whether the changes from sea to land and back again, came from oscillations of the area itself or changes in the bed of the ocean is of great importance in considering the possibilities of gas and oil within the area. For if they were due to rising and lowering of the land (both very slow processes), it must have followed, as shown by the rocks of all land areas, that some parts moved more than others, while the general movements were in progress. If so, this meant a bending of the beds making up the different formations above described, and this resulted in the formation of anticlines and synclines; and this in turn formed reservoirs in which oil and gas might collect.

If on the other hand, the advances and withdrawals of the sea were due to changes in the sea level, the rocks of the area would not be flexed, for they would have been left quiet through the changes in geography.

Such anticlines and synclines as may exist probably had their inception during the elevation that followed the Lower Cretaceous deposition, and were enlarged during those that followed the close of the Upper Cretaceous and the Tertiary. For it is a principle of geology pretty well established that a fold beginning in any period of movement is intensified during subsequent similiar movements. High folds with strong dips can not be expected in the Reelfoot Lake district, or elsewhere in the Embayment area. The anticlines, if they exist, are low and flat.

The formations of the Embayment area that may contain oil and gas are covered with more recent ones, so that it is very difficult to locate such folds as may exist without many more deep well records than are now to be had. In fact with our present knowledge, the location of the folds and consequently of promising well sites, seems impossible except perhaps in limited areas. The only criteria in conjecturing their shape is in the structure of the older rocks surrounding the Embayment area. In those along and east of the Tennessee River in Tennessee and in those bordering the Embayment area in Kentucky, Illinois, Missouri and northeastern Arkansas, the folds are not in elongated anticlines and synclines, but are more nearly in the shape of domes and intervening basins. In central and southwestern Arkansas, the folds in the old rocks west of the Embayment are distinct east and west anticlines and synclines.

With these facts in mind, the geologist in directing pioneer oil and gas prospecting in the Embayment would proceed on the hypothesis that the folding in the area being drilled would be similiar in shape to that of the nearest old rocks on the border. The floor of the Embayment area is the continuation of these old rocks and their structure probably was transmitted to the new ones above, in times of its oscillation.

WELLS OF THE EMBAYMENT AREA.

Because the geology of the Reelfoot district is similiar to that of at least the northern half of the Embayment area, light may be thrown on the possible oil conditions of the former by taking a glance of what is known of the latter. That is what has been attempted in this paper. If the wells of the area were numerous enough, deep enough and well enough distributed, they would disclose the structure, which is the needed information in locating wells for oil and gas; but they are not numerous, not many are deep and such deep ones as have been put down are near the central line of the area.

Numerous wells have been sunk at Memphis for a city water supply, but as a rule these have stopped in the Lagrange formation, and are less than 1,000 feet deep, though at least one has gone to the depth of 1,583 feet. If any of them have reported gas or oil, the writer is not aware of it.

From 1909 to 1911 four wells were put down for oil and gas, on an island that then lay just west of Loosa Hatchie and Wolf rivers at Memphis. The writer is informed that since that time the course of the Mississippi has so changed as practically to remove that part of the island where the wells were sunk. These wells are respectively 1,793 feet, 1,017 feet, 1,250 feet and 2,517 feet deep.* It appears that all of them produced a small amount of gas, and possibly some of them a little oil.

At this writing, a well is being sunk, with a rotary drill, on the east side of Reelfoot Lake, a mile and a half south of Samburg, under the direction of Mr. J. W. Scott of Pittsburg, Pennsylvania. As yet, no log of this well has been furnished this Survey; but when last visited by the writer, Nov. 11, 1915,

---

*For a full description of wells Nos. 1, 2 and 3, see Munn, M. J., *Resources of Tennessee,* Vol. II, No. 2, pp. 48-68. Well No. 4 was not completed when Mr. Munn's paper was prepared. Concerning well No. 4, Mr. C. H. Trimble, of Memphis, stated in a letter to the present writer that there were "showings of what appeared to be gas at many places on the way down, and there was apparently gas at the lowest depths reached. There were also several showings of what the driller pronounced to be oil, but nothing commercial." As to the material passed through, Mr. Trimble says, "I have not the log of this latter well, but it was put down to a depth of 2517 feet, and stopped in clay very much like the Porters Creek clay." The well was sunk with a rotary drill.

it was reported by Mr. Scott to be approximately 2,000 feet deep. The drill was in very tough, dark blue clay that the drillers called gumbo. Mr. Scott said that at 270 feet, a 2-foot oil sand was struck that he thought would produce five barrels of oil a day; that from 1,230 to 1,457 feet, the drill passed through sand with a showing of oil all the way, but especially in its upper and lower 30 feet; and that a little gas was struck in the upper 30 feet of the sand. He estimated that the total output from the sand would be from 20 to 30 barrels a day.

Mr. M. J. McGinnis, City Clerk of Caruthersville, Missouri, stated in a letter that a well was sunk there 1,550 feet for water, and that no indications of oil or gas were found in drilling.

Mr. J. W. Rhores, Jr. of Osceola, Ark., reports that the water supply for that city comes from the depth of 1,450 feet; for Wilson, Ark., from a depth of 1,690 feet; and from Marked Tree, Ark., from 2,200 feet. So far as the writer is informed, none of these showed indications of oil or gas.

DIFFICULTY IN LOCATING WELLS.

In areas of old rocks, such as those surrounding the Embayment area, the geologist can, with comparative ease, locate the places where oil or gas might be secured and the areas or localities where there is no chance for them. In most areas, such as Middle Tennessee, most of Kentucky, Pennsylvania, West Virginia, Oklahoma, or that part of Arkansas west of the Embayment area, an operator would be very foolish to put down a well without the advice of a competent geologist. But in the Embayment area, where almost the entire surface is so completely covered with recent deposits as to hide all the usual indications of the structure, the work of a geologist in locating prospective wells would be difficult and might prove futile. As has been suggested to the writer by Dr. Glenn, it is possible that a study of the bluffs from Hickman southward to Memphis might reveal a north-south difference in structure; and that light might be thrown on the structure away from the river by careful use of railroad and drainage profiles.

While a large number of deep well records would be of the greatest assistance of any data that future developments may furnish, these must be used with the fact in mind that a period of erosion followed the deposition of both the Lower and the Upper Cretaceous beds. In other words, these have been in part removed, and in this the tops of the folds probably suffered most. This being true, a well on an anticline might not reach one of these formations at a less depth than a neighboring one on a syncline. Especially could this be true if the folds are comparatively small.

At present, the only suggestions the writer can give prospectors in the Tennessee part of the Embayment area are to keep well away from its borders, locate near railroads where supplies are easily obtained, and when the well is once started go to the old rock floor before stopping.

CONCLUSIONS.

1. The formations of the Embayment area probably contained enough organic matter at the time of their deposition to produce a good supply of oil and gas.

2. Around the edges of the Embayment area, where the formations are exposed, they consist of alternating beds of sand and clay. The deep wells that have been sunk at Memphis and Reelfoot Lake indicate that beds of sand, though fine-grained, occur at practically all depths penetrated by the wells. These sand beds, lying as they do, between beds of clay, should form gas and oil reservoirs if the beds are folded.

3. The elevations and depressions that have occurred in the area make it probable that slight folding has taken place.

4. While none of the four wells sunk at Memphis produced oil or gas in commercial amount and while the one on Reelfoot Lake has not as yet been proved to be a commercial well, the reports show that all these produced gas in small amount and some of them made good showings of oil. This, if the drillers were not mistaken, proves the presence of these products, and if they exist at all it stands to reason that in places they may occur in paying quantities.

5. The deep well records at Memphis and Reelfoot Lake indicate that the Cretaceous deposits thicken in the middle of the Embayment area. This is not surprising, for it is this part of the area that probably was first occupied by the sea in both

Lower and Upper Cretaceous times, and equally probable that it was the last to be vacated. Granting that these conditions were true, it was the area of longest deposition, and consequently the thickest deposits should be expected there.

6. As above stated, any well started should be sunk to the old hard rocks upon which the Cretaceous beds rest, unless commercial amounts of oil or gas should be struck before that depth is reached. To the present, no prospective gas or oil well has reached these old rocks, but their top is probably not very far below the point reached in the deepest drill hole at Memphis and in the one at Reelfoot Lake.

7. It must be understood that no assurance can be given of a successful well in an undeveloped area, but if prospecting should be continued in the Reelfoot district, the low flat anticline described by Mr. Fuller* as the Tiptonville dome should be the guide to it. The wells should be sunk near a straight line beginning some 4 miles south of Tiptonville and running just east of that place, toward New Madrid. The northern limit of the area is about half way between the State line and New Madrid, in the loop of the river.

8. The Caddo oil field of northwestern Louisiana is located on a structural dome, and the oil comes from the Upper Cretaceous† the deposits which are similar in character to those of Tennessee. This lends encouragement to the formation being oil bearing in Tennessee, provided the necessary structural conditions occur.

9. The formations considered in this paper are those of Cretaceous and Tertiary age. As far as our knowledge of them goes, it is not impossible for the old rocks that form the floor of the Embayment, in places to contain oil and gas; but the difficulty in locating wells in them is even greater than in the younger rocks above.

---

*[*Loc. cit.*]

†Harris, G. D., U. S. Geol. Surv., Bull. 429, pp. 127-8.

An Interesting Case of Spontaneous Combustion

By Paul C. Bowers.

The burning of a large pile of black shale dumped at the edge of the Tennessee River, a little south of Hamburg, has caused considerable excitement and interest in Hardin County because of its spontaneous origin, and long duration. A description and explanation of this rather remarkable incident may be of interest to the readers of this publication.

The U. S. Government has been dredging the shallow place in the Tennessee River south of Hamburg and a canal, about two miles long, has been excavated out of the rock in the bed of the river. The rock was piled in the water at the edge of the river and consisted mostly of limestone, but for a distance of about a hundred yards the pile was the typical Chattanooga shale. This shale contained a great deal of bituminous matter, even a few pieces of thin lenses of coal, some oil and a considerable quantity of pyrite and marcasite.

Pyrite and marcasite are chemical compounds of iron and sulphur. They both have a pale brass-yellow color and resemble each other very closely. Marcasite is more easily decomposed than pyrite and nearly always has a greenish-white, varying to white, powder on its surface. This powder is a mineral, known as melanterite, sometimes called vitriol or copperas. Its chemical name is sulphate of iron. It is soluble in water and tastes like a mixture of iron and alum. This is the first decomposition product of marcasite and pyrite.

About the 15th of August, 1915, after several days of rain and high water this pile of black shale started burning just above the high water mark. The fire continued over a period of about two months extending along the pile for a distance of seventy-five yards. It was a slow smouldering fire and when fanned by the wind would burst into flames. There was a constant cracking noise which was due to the cracking of the shale by the gas formed on heating the pyrite. Sulphur fumes were very strong, and, as reported by Mr. Bruce Wade, who was doing geological work in this area at the time, the odor was detected at a distance of some miles. They attacked the paint on the Government boats and turned it to a dirty color because the lead carbonate of the paint was changed to a sulphide. These fumes also killed the leaves on the trees nearby. A thin coating of sulphur was formed on the surface of the shale dump. Considerable melanterite or copperas has also been formed in the burned portion of the dump.

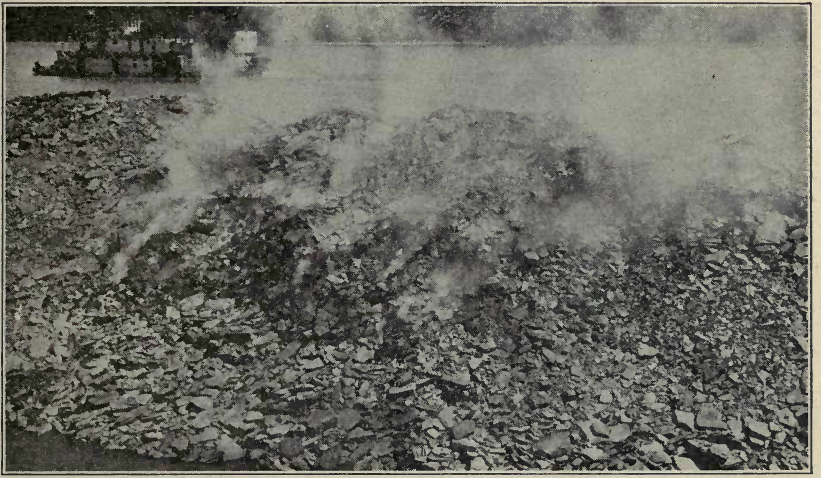
In order to explain the cause of this phenomenon a little physical chemistry must be considered.

Oxidation in the strict sense of the term is a chemical change in a substance whereby the substance unites with oxygen, which generally comes from the air. This is the change by which iron is converted into iron rust, and wood, coal, and other carbonaceous materials are converted into carbon dioxide, when they burn. All combustible substances under ordinary conditions are constantly being oxidized at the surface and when oxidation takes place, heat is always formed. But the oxidation is so slow that the heat formed is radiated and lost as fast as it is formed. When heat is applied to the substance, the rate of oxidation is increased. When the oxidation is so rapid that light and heat, perceptible to the senses, are evolved, the substance is said to burn or undergo combustion. Combustion is, therefore, rapid oxidation.

When a substance is oxidized at the natural, slow, gradual rate and when conditions are such, that the heat produced by this oxidation is not radiated and lost as fast as produced, the heat accumulates and thus increases the rate of oxidation. This in turn causes more heat to be formed; which again causes more oxidation; and in this way, the oxidation of the substance finally becomes so rapid as to cause the substance to burn. When all this takes place without external aid, we have spontaneous combustion.

Oxidation takes place more rapidly in the presence of moisture, or in a moist atmosphere than under dry conditions. In fact oxidation is so slow in a dry atmosphere that it may hardly be noticed. Oxygen in large quantities is found dissolved in rain water and fresh water, such as is present at flood time, as a result of its fall through the air. Analyses of rain water show that about 30 per cent of the dissolved gases is oxygen. Thus in rain water, oxygen is in its most active form under natural atmospheric conditions, and oxidation of combustible matter takes place more rapidly in its presence.

This pile of black shale had all of the conditions and essentials for spontaneous combustion. The high content of combustible material in the shale, such as marcasite, pyrite, oil and bituminous matter, furnished the fuel for the fire. The rain water with its high oxygen content and the air slowly circulating through the pile, supplied the oxygen for oxidation. The shale was a poor conductor of heat so that the heat from oxidation was not lost through radiation but accumulated within the pile.



Burning of Chattanooga shale in the Tennessee River near Hamburg, from spontaneous combustion.

The marcasite in a finely divided condition and, to a less extent, the pyrite, was very readily oxidized by the moist air and by the rain water with its high oxygen content, clinging to the surface of the marcasite just above the water line. This was the starting point of the spontaneous combustion. The heat produced by the oxidation of the marcasite was retained by the shale and thus enhanced the oxidation. In this way the rate of oxidation kept increasing and the heat accumulating. As the temperature rose, the other combustible materials were oxidized, and when it reached a certain temperature, the oil ignited. Then all the combustibles burned and we had the phenomenon of spontaneous combustion.

In the complete oxidation or combustion of pyrite and marcasite, iron oxide or rust and the gas, sulphur dioxide, are formed. This gas is largely the sulphur fumes given off in the burning of the shale and is the same as that given off from a burning sulphur match. It attacked the leaves of the trees, etc., and caused the offensive odor of the burning shale. It is soluble in water, and because there was a great deal of moisture on the shale, this gas was dissolved, and caused all the shale to have an acid taste.

A small amount of sulphuretted hydrogen gas was formed by the action, in the presence of moisture, of the sulphur dioxide, from the burned pyrite, on the pyrite of the shale, which had not yet burned. This was the gas of the fumes which attacked the white paint on the boats and changed some of the white lead carbonate of the paint to black lead sulphide, thus causing the dirty color.

When the supply of oxygen is rather limited, as was the case in some parts of this pile of shale, the marcasite and pyrite are only partially oxidized. In this case iron sulphate and free sulphur would be formed. The heat volitilized the sulphur, which, on cooling at the surface, condensed, and was deposited as crystals and yellowish white powder on the surface of the pile of shale. The iron sulphate left behind in place of the pyrite or marcasite, on cooling took up water and formed crystals of green vitriol or copperas. These crystals, however, on exposure to the air, lose some water and crumble to a white powder, which was its form in the burned shale.

The burning of shale is no ordinary occurrence but is possible when there is a large amount of combustible material in it. The spontaneous combustion of shale, however, is very rare, and this phenomenon is worthy of record.

Sketch of the Work Done by the State Geological Survey in 1915

In the first part of the year Mr. Dandridge Isom was employed in keeping logs of oil wells in the Oneida district, Scott County. During the summer, Mr. H. F. Bain was employed to do this work.

In co-operation with the U. S. Bureau of Mines and the U. S. Geological Survey, something like four hundred coal samples were taken for analysis, and the analyses were made at the laboratory of the Bureau of Mines at Pittsburg, the chemist of the Survey, Dr. Paul C. Bowers, assisting in the work. Dr. L. C. Glenn, in charge of the coal work, spent something like a month in the field, and the remainder of the summer until October in the preparation of the report on coal.

Mr. C. R. Watkins, Jr., F. W. Farnsworth, and A. P. Miller were engaged in the field work for a map of McNairy County, which was completed; and in the mapping of a part of Hardin County, and a part of Decatur County. In September Mr. Watkins was transferred to Shelby County where he is yet employed. Mr. Farnsworth was employed during March and April, and Mr. Miller from June until September. These county maps are intended as bases for geological and soil maps.

In co-operation with the Agricultural Experiment Station, University of Tennessee, Messrs. G. M. Ferris and F. M. Maloney were employed during the summer in the preparation of a map of Rutherford County, also to serve as a base for soil and geological maps.

Beginning with May, Mr. Bruce Wade was employed until October on geological work in McNairy and Hardin counties, having finished the former.

Beginning with June, Dr. J. J. Galloway and H. N. Coryell were employed, in co-operation with the Agricultural Experiment Station, University of Tennessee, in mapping the geology of Rutherford County, which was completed.

Until July, Mr. O. P. Jenkins was employed in the preparation of a bulletin on the correlation and general description of the geological formations of Tennessee. Beginning with July, he was sent to Johnson County to investigate the new phosphate discoveries of that locality, which work kept him until November. Since that time, he has been employed in the preparation of a report upon these phosphates.

Beginning with September, a soil survey of Shelby County was undertaken, in co-operation with the U. S. Bureau of Soils, Mr. R. T. Allen being put in charge of the work. This is still in progress.

During the year Dr. C. H. Gordon has put in such time as he could spare from his duties as Professor of Geology in the University of Tennessee, in the preparation of a bulletin on the marbles of Tennessee.

During the whole of the year, with the exception of the time required for trips to investigate general forest conditions in different parts of the State, Mr. R. S. Maddox, Forester, was employed in efforts toward the reclamation of gullied lands in West Tennessee. Most of his time was consumed in the field in direct touch with the farmers who own the waste lands, though he has written a few articles for publication.

Dr. Paul C. Bowers, the chemist of the Survey, has been employed in making coal analyses, phosphate analyses, and in doing such other general chemical work as has been required of the Survey.

Miss Elizabeth Cockrill spent such time as she could spare from her duties as secretary, in the preparation of a bulletin on elevations in the state.

The administrative report of the State Geologist appeared in the early part of the year. Four issues of the "*Resources of Tennessee*" were published, containing articles on the economic mineral resources of the state. A map of Lewis County, showing iron banks and mines, the streams and the cultural features was published, as was also a geological map of the state.

A. H. P.

Publications of Geological Survey of Tennessee Issued.

The following publications have been issued by the present Survey, and will be sent on request *when accompanied by the necessary postage.* Gaps in the series of numbers are of reports still in preparation:

Bulletin No. 1—Geological Work in Tennessee.

A. The establishment, purpose, object and methods of the State Geological Survey; by Geo. H. Ashley, 33 pages, issued July, 1910, postage, 2 cents.

B. Bibliography of Tennessee Geology and Related Subjects; by Elizabeth Cockrill, 119 pages; postage, 3 cents.

Bulletin No. 2—Preliminary Papers on the Mineral Resources of Tennessee, by Geo. H. Ashley and others.

A. Outline Introduction to the Mineral Resources of Tennessee, by Geo. H. Ashley, issued September 10, 1910; 65 pages; postage, 2 cents.

D. The Marbles of East Tennessee, by C. H. Gordon; issued May, 1911; 33 pages; postage, 2 cents.

E. Oil Development in Tennessee, by M. J. Munn; issued January, 1911; 46 pages; postage, 2 cents.

G. The Zinc Deposits of Tennessee, by S. W. Osgood; issued October, 1910; 16 pages; postage, 1 cent.

Bulletin No. 3—Drainage Reclamation in Tennessee; 74 pages; issued July, 1910; postage, 3 cents.

A. Drainage Problems in Tennessee, by Geo. H. Ashley; pages 1-15; postage, 1 cent.

B. Drainage of Rivers in Gibson County, Tennessee, by A. E. Morgan and S. H. McCrory; pages 17-43; postage, 1 cent.

C. The Drainage Law of Tennessee; pages 45-74; postage, 1 cent.

Bulletin No. 4—Administrative Report of the State Geologist, 1910; issued March, 1911; postage, 2 cents.

Bulletin No. 5—Clays of West Tennessee, by Wilbur A. Nelson; issued April, 1911; postage, 4 cents.

Bulletin No. 9—Economic Geology of the Dayton-Pikeville Region, by W. C. Phalen, for sale only, price 15 cents.

Bulletin No. 10—Studies of the Forests of Tennessee.

A. An Investigation of the Forest Conditions in Tennessee, by R. Clifford Hall; issued April, 1911; 56 pages; postage 3 cents.

B. Chestnut in Tennessee, by W. W. Ashe, issued December, 1911; postage, 2 cents.

C. Yellow Poplar in Tennessee, by W. W. Ashe, issued January, 1914; 55 pages; postage, 3 cents.

Bulletin No. 13—A Brief Summary of the Resources of Tennessee, by Geo. H. Ashley; issued May, 1911; 40 pages; postage, 2 cents.

Bulletin No. 14—The Zinc Deposits of Northeastern Tennessee, by A. H. Purdue; issued September, 1912; 69 pages; 30 illustrations, postage, 3 cents a number.

Bulletin No. 15—Administrative Report of State Geologist, 1912.

Bulletin No. 16—The Red Iron Ores of East Tennessee, by E. F. Burchard; issued November, 1913; 172 pages; postage, 8 cents.

Bulletin No. 17—The Water Powers of Tennessee, by J. A. Switzer; issued April, 1914; 137 pages; postage, 8 cents.

Bulletin No. 18—Administrative Report of the State Geologist, 1914.

Maps—Map of Lewis County, 1915; postage, 2 cents.
Geological Map of Tennessee, 1915; postage, 10 cents.

"THE RESOURCES OF TENNESSEE."—This is a quarterly magazine, devoted to the description, conservation and development of the State's resources. Postage, 2c a number. The following are the volumes and numbers issued, with the titles of the principal papers in each number:

Vol. I. No. 1—The utilization of the small water powers in Tennessee, by J. A. Switzer and Geo. H. Ashley.

No. 2.—The Camden chert—an ideal road material, by Geo. H. Ashley.
The Fernvale iron ore deposit of Davidson County, by Wilbur A. Nelson.
Cement materials in Tennessee, by C. H. Gordon.

No. 3—The gold field of Coker Creek, by Geo. H. Ashley.

No. 4—Coal resources of Dayton-Pikeville area, by W. C. Phalen.

No. 5—Economic aspects of the smoke nuisance, by J. A. Switzer.
Watauga Power Company's hydro-electric development, by Francis R. Weller.
The coal fields of Tennessee, by Geo. H. Ashley.

No. 6—Bauxite Mining in Tennessee, by Geo. H. Ashley.
A New Manganese Deposit in Tennessee, by Wilbur A. Nelson.
Road Improvement in Tennessee, by Geo. H. Ashley.

Vol. II. No. 1—The Utilization of the Navigable Rivers of Tennessee, by Geo. H. Ashley.
Dust Explosions in Mines, by Geo. H. Ashley.
The Rejuvenation of Wornout Soil Without Artificial Fertilizers, by Geo. H. Ashley.
Tennessee to Have Another Great Water Power, by George Byrne.
Manufacture of Sulphuric Acid in Tennessee in 1911, by Wilbur A. Nelson.

No. 2—The Ocoee River Power Development, by J. A. Switzer.
Exploration for Natural Gas and Oil at Memphis, Tenn., by M. J. Munn.

No. 3—The Power Development at Hale's Bar, by J. A. Switzer.
Notes on Lead in Tennessee, by Wilbur A. Nelson.

No. 4—The Tennessee Academy of Science.
The Preliminary Consideration of Water Power Projects, by J. A. Switzer.
Lignite and Lignitic Clay in West Tennessee, by Wilbur A. Nelson.

No. 5—The Growth of Our Knowledge of Tennessee Geology, L. C. Glenn.

No. 6—On the Impounding of Waters to Prevent Floods, by A. H. Purdue.
Drainage Problems of Wolf, Hatchie, and South Fork of Forked Deer Rivers, in West Tennessee, by L. L. Hidinger and Arthur E. Morgan.
The Waste From Hillside Wash, by A. H. Purdue.

No. 7—Where May Oil and Gas Be Found in Tennessee? By Geo. H. Ashley.
Spring Creek Oil Field, by M. J. Munn.

No. 8—The Monteagle Wonder Cave, by Wilbur A. Nelson.
Cave Marble (Cave Onyx) in Tennessee, by C. H. Gordon.

No. 9—The Valley and Mountain Iron Ores of East Tennessee, by Royal P. Jarvis.

No. 10—The Iron Industry of Lawrence and Wayne Counties, by A. H. Purdue.
Some Building Sands of Tennessee, by Wilbur A. Nelson.

No. 11—Tests on the Clays of Henry County, by F. A. Kirkpatrick. Introduction, by Wilbur A. Nelson.
Barite Deposits in the Sweetwater District, by Herbert B. Henegar.

No. 12—The Soils and Agricultural Resources of Robertson County, by Reese F. Rogers.
The Iron Ore Deposits in the Tuckahoe District, by C. H. Gordon and R. P. Jarvis.

Vol. III. No. 1—The General Features of the Tennessee Coal Field North of the Tennessee Central Railroad, by L. C. Glenn.
The Tennessee Coal Field South of the Tennessee Central Railroad, by Wilbur A. Nelson.

Vol. III. No. 2—State Supervision of Forestry, by L .C. Glenn.
Conservation of the Water Powers of Tennessee, by J. A. Switzer.
Water Supplies for Cities and Towns, by A. H. Purdue,
Types of Iron Ore Deposits in Tennessee, by C. H. Gordon.
The Causes and Nuisance of Smoke, by Wilbur A. Nelson.
Geology and Engineering, by A. H. Purdue.

Vol. III. No. 3—The Gullied Lands of West Tennessee, by A. H. Purdue.
White Rock Phosphate of Decatur County, Tennessee, by T. Poole Maynard.
Mineral Products Along the Tennessee Central Railroad, by Wilbur A. Nelson.
Relations of Water Supply to Health, by J. A. Switzer.

Vol. III. No. 4—Minerals of Tennessee, Their Nature, Uses, Occurrence and Literature, by A. H. Purdue.
Building Precautions Against Earthquake Disasters, by Olaf P. Jenkins.

Vol. IV. No. 1—Relation of Water Supply to Health, by J. A. Switzer.
Earthquakes in East Tennessee, by C. H. Gordon.
The State Geologist and Conservation, by A. H. Purdue.
A. Tripoli Deposit near Butler, Tenn., by L. C. Glenn.

No. 2—The Brown and Blue Phosphate Deposits of South-Central Tennessee, by J. S. Hook.
Discussion, Lucius P. Brown.
Bauxite in Tennessee, by A. H. Purdue.

No. 3—Economic Geology of the Waynesboro Quadrangle, by N. F. Drake.
Recent Water Power Development in Tennessee, by J. A. Switzer.
Two Natural Bridges in Tennessee, by Hugh D. Miser.
Road Materials of Tennessee, by A. H. Purdue.
Report on the Water Powers of Tennessee.

No. 4—The Need of a Soil Survey of Tennessee, by C. A. Mooers.
The Geology of Perry County and Vicinity, by Bruce Wade.
Indexes to Volumes III and IV.

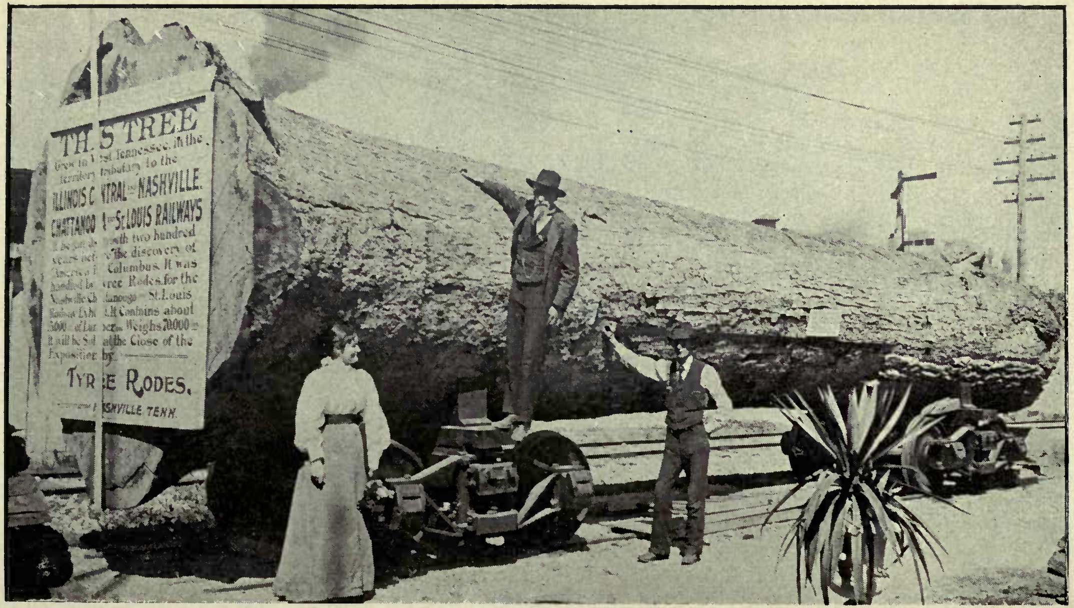
Vol. V. No. 1—The Hydro-Electric System of Tennessee, by J. A. Switzer.
West Tennessee Gullied Lands and Their Reclamation, by R. S. Maddox.
The White Phosphates of Tennessee, by J. S. Hook.

No. 2—Physiographic Influences in the Development of Tennessee, by L. C. Glenn.
Care and Protection of Forests, by R. S. Maddox.
Two Natural Bridges of the Cumberland Mountains, by Wilbur A. Nelson.

No. 3—The Iron Ore Deposits of Lewis County, Tennessee, by Reese F. Rogers.

No. 4—The Soils of Tennessee, by C. A. Mooers.
Recent Development near Oneida, Scott County, Tennessee, by L. C. Glenn.

The supply of Vol. 1 No. 2, Vol. III No. 1, and Vol. V No. 1, is exhausted.



LARGE POPLAR (LIRIODENDRON TULIPIFERA) SHOWN IN THE EXHIBIT OF NASHVILLE, CHATTANOOGA, AND ST. LOUIS RAILWAY, CENTENNIAL EXPOSITION, NASHVILLE, TENN.

7 Walter Mulford
1905

THE

FORESTS OF TENNESSEE:

THEIR EXTENT, CHARACTER, AND DISTRIBUTION.

BY GEORGE B. SUDWORTH,
Dendrologist, Division of Forestry, U. S. Department of Agriculture,
AND
J. B. KILLEBREW, A.M., PH.D.,
Former Commissioner of Agriculture, Statistics, and Mines for the State of Tennessee, and at Present Immigration Agent of the Nashville, Chattanooga, and St. Louis Railway.

ISSUED BY THE PASSENGER DEPARTMENT OF THE
Nashville, Chattanooga, and St. Louis Railway.

COPYRIGHTED, 1897, BY THE
NASHVILLE, CHATTANOOGA, AND ST. LOUIS
RAILWAY.

NASHVILLE, TENN.:
PUBLISHING HOUSE OF THE M. E. CHURCH, SOUTH.
BARBEE & SMITH, AGENTS.

INTRODUCTORY.

THE two papers on the forests of Tennessee embraced in this pamphlet were read at a meeting of the American Forestry Association held in Nashville in one of the buildings on the Centennial Grounds September 22, 1897. They were listened to with the greatest attention by a highly cultivated and appreciative audience. The destructive agencies now in operation will soon sweep from this country the last vestige of the primeval forests, which have been the wonder and admiration of Europe and should be the pride of the people of the New World. The addresses contained in this pamphlet have reference especially to the extent, character, and distribution of the forest-trees in Tennessee. The first settlers in the state found the whole country covered by a solemn, mysterious, and seemingly interminable forest. There was not a foot of prairie land in the state, unless the bald spots on the tops of the higher mountains may be so called. There were no breaks in the continuity of the woodlands, except on a few rocky points and in some narrow, winding openings where the streams flowed. For miles and leagues there was a shadowy canopy of arboreal growth, in which the deadly reptile lay concealed and the savage enemy lurked and the bear and the wolf, the deer and the panther, found a safe refuge during the day from their common enemy, man. To the pioneers it must have been a dismal sight to find all the land shrouded in the deep gloom of the forest, to catch but seldom the cheering rays of the summer sun, to walk at midday through the dark and melancholy woods that stretched from mountain to valley, from plain to river, from state line to state line.

It was not until about the year 1850 that land-owners in the best agricultural districts of Tennessee began seriously to consider the necessity of taking care of their wooded lands — not for lumber, but for fire-wood. At that period there was very little stone-coal used in the state. Blacksmiths even used charcoal for fuel, as also did the iron furnaces in every division of the state. The consumption of coal in Nashville in 1831, when the first grate was erected, did not reach one thousand bushels, or forty tons, per annum. From 1836 to 1860 coal was worth by retail from twenty to fifty cents per bushel, and for the latter year about thirty-six thousand tons only were required to supply the demands of Nashville and the mills in its vicinity. Nearly all the hotels, steamboats, railroads, and private dwellings used wood for fuel. But the price for wood gradually advanced, and that for coal declined with increased demand and the opening of new sources of supply, until coal for fuel came to be used in the cities almost exclusively.

The iron furnaces continued to use charcoal until 1869, when coke was first employed in the production of pig-iron. In the meantime the farmers never relaxed their efforts in opening new lands, but the acreage was reduced to the limit necessary to supply fire-wood for the farm, rails for fences, and in the tobacco districts wood for the burning of plant-beds and the curing of tobacco. Sawmills, however, multiplied more rapidly after 1870, and lumber found a ready market all over the country rendered accessible by river or railway. The shipment of staves, spokes, hubs, and handles to Europe, as well as to every portion of the United States, increased almost in a geometrical ratio. At present it may well be a question of deep solicitude with the people of Tennessee as to what the next generation will do for lumber. From what region will it come? The present accelerated yearly consumption will use up all the most valuable forests in the United States within the next twenty-five years.

And yet it is true that timbered lands are as cheap in Tennessee to-day as they were thirty years ago. It is difficult to give a satisfactory reason for this state of things. It may be because such large areas are offered in the market. It is nevertheless true that such lands may now be bought for less than one-third the price of what the same character of lands will sell for in the Northern states.

J. B. KILLEBREW.

THE FOREST FLORA AND CONDITIONS OF MIDDLE AND EAST TENNESSEE.*

BY GEORGE B. SUDWORTH,

DENDROLOGIST, DIVISION OF FORESTRY, U. S. DEPARTMENT OF AGRICULTURE.

IN the short space of time allotted I can not hope to give any but a very rapid survey of the forest conditions of Middle and East Tennessee, a mere impression of the volumes possible to tell of its great forest resources.

Perhaps one who has never traversed this long, narrow state, and who compares it on the map with its neighbor states, is apt not to be so wonderfully impressed with what Tennessee really contains. Its appearances are, however, very deceiving. There is no other Southern state which can compare with Tennessee in the valuable timber resources it has had and now has. There is no other Southern state that comprises within its length and breadth the same widely diversified forest conditions.

Glancing over its present three great natural geographical divisions (East, Middle, and West Tennessee), it is the middle ground where nearly all the important Northern timber trees meet with those of corresponding importance from the South. Incidentally we may say in parentheses, too, that Tennessee is the land where our large Eastern forest-trees grow larger and our smallest trees grow largest. Species that mophologically must be classed as trees, though elsewhere mere bushes in size, are, when found in the forests of Tennessee, veritable trees in stature. The great cottonwoods, tulip-trees, and sycamores of the Mississippi Valley lands are unsurpassed in their gigantic size, while the huge yellow poplars and black cherries of East Tennessee are equaled by few from any other states and surpassed by none.

---

*Read before the autumn meeting of the American Forestry Association held in Nashville, September 22, 1897.

But we must speak only of Middle and East Tennessee, and especially of the latter division. The middle division of Tennessee, including the great blue-grass region, is forestally less interesting than the eastern division. It contains the prize agricultural lands of the state, producing such quantities of tobacco, cotton, wheat, and sweet potatoes as are nowhere else to be found. I need not describe them; fair samples are to be found among the agricultural exhibits. But originally this region was the home of the largest red cedar and the finest black walnut and poplar. To-day, as one travels through these fertile districts, there is little to remind you of the great wealth of red cedar timber, now practically gone from the rich, tillable lands. In fact, if you did not look sharply, you would not discover that the miles and miles of gray-brown, two-or-three-hundred-year-old looking rail fences are of good old red cedar. It must have been very common and its virtue of outlasting men and things well known. I do not know whether the old Tennesseeans who split those rails were, from their abundance, guilty also of using red cedar for fire-wood or not, but suspect that they were, as even now people dare to burn the stumps for this purpose. It is eminently the greatest cedar region of the South. Red cedar is found in nearly every county of the state, but a circle of counties to the east and south of Nashville—including Wilson, Rutherford, Marshall, Fentress, Overton, Davidson, Pickett—comprises the region of old and new supply from which about all the commercial cedar of the state was and is now derived.

But, although the red cedar is forever gone from these fertile lands, it still remains on small and large areas, as the case may be, of exposed limestone and otherwise barren knobs, which are scattered throughout the region. These spots, from one-half to fifty or more acres, give one the impressive idea that red cedar grows here because it can not help it. A large amount of this cedar now left is of young growth, with low-branched crowns and trunks small enough to escape doing duty as telegraph-poles, though somewhat in danger for small fence-posts. Nearly all of these counties, too, have their small bodies of prime old cedar, in most cases standing on limestone, which have escaped the ax of the pencil-maker, and especially the piling and telegraph-pole gentlemen. It should be said, however, that all such miraculous escapes are due to the fact that the timber could not be bought for one or another reason. The local buyers know every old tree for miles, and one told me he was only waiting for an owner to die, whose heirs he knew would sell as soon as they had the power. And so I believe that, were it possible for buyers to lay hands upon all the sizable cedar timber now, it would not last over five years, if it did that long.

The virgin red cedar of Middle Tennessee is often several centuries old, and in some cases very large. Although really large cedar is at present but rarely seen, through the courtesy of several public-spirited manufacturers, I saw some fine, sound timber, the butt log squaring in one case thirty-seven inches, with an estimated age of two hundred and ninety years, and averaging about three twelve-foot logs to the tree. But I noticed that the owner of these logs was careful to lock the door after we left the storehouse.

While we should never expect to see the good farming-lands of Middle Tennessee again clothed with large cedar and other timber, as in days gone by, the farmer forester of to-day has little to do but keep out fire and grazing stock from the rocky waste land on the farm to see it bristle with young red cedars. They refuse to grow only where there are no fissures in the exposed rock, and elsewhere often form dense forest-covers under conditions too dry and barren for any other tree.

Although the general impression one receives in traveling through Middle Tennessee is one in which red cedar is the dominant feature, there are, nevertheless, many characteristic broad-leafed trees; but the greater abundance of this class of trees lies in the eastern division of the state. The specially fertile character of the soil in the blue-grass region has resulted, through clearing, in the practical disappearance of all large bodies of hardwood trees wherever the farms are of uniformly good land. The often almost total lack of farm wood-lots is a feature that strikes the stranger. The courses of large and small streams usually have fringes of hard woods, areas which broaden out wherever the land becomes unagricultural, that is, composed of surface lime and other rock. The remnant old forest-trees in rich, moist bottoms are usually large, and consist principally of tulip-tree, white, red, green, and blue ashes, white oak, chestnut oak, bur oak, cow oak, overcup oak, chinquapin oak, red, yellow, and Texas oaks, together with red, black, sugar, and ash-leaved maples. The white linden, or basswood, which is the peculiar Tilia of Southern forests, is a large timber tree throughout Middle Tennessee, scattered in single or groups of a few individuals along the streams or here and there over the dry, rocky hills. One sees an occasional silver-leaf maple, black willow, water and honey locust, box-elder, winged and American elms, and also the adaptive Southern hackberry, occupying the low, clayey spots. The upland wooded areas are further characterized by several distinct soil conditions, three of which are very common. Poor, dry, gravelly, and clayey hills and knobs have beech, white oak, red oak, pignut, mockernut, and shellbark hickory, and sometimes here and there a red cedar. Then, again, one meets a richer, clayey loam with frequent outcroppings of shaly limestone, in places running out into large areas of exposed, deeply fissured lime rock, where the characteristic forest-trees are sugar maples, beech, white basswood, red and yellow oaks, white and chinquapin oaks, bitternut, shagbark and shellbark hickory, red mulberry, Southern hackberry, white and blue ashes, honey locust, hop hornbeam, and many smaller, unimportant trees.

The extensive areas of exposed lime rock, with numerous deep fissures, is in spots often strangely well clad with fairly well-grown, open stands of sugar maple, white ash, white oak, chinquapin oak, and white basswood. The sugar maple here shows its ready adaptation to bare, rocky sites, its big roots rambling over the rocks and searching out accumulated mold in the deep fissures; and one sees the special fitness of the often-applied common name, rock maple. Its other companions named are seeking the large pockets and wider gaps in the rocks where time has formed and laid up some depth of soil. In still other localities, as already noted, these bare limestone glades may run into almost pure growths of red cedar, while in other sections these rocky areas may have only the scattered characteristic chinquapin oak (*Quercus acuminata*) and occasional blue ash.

A third very interesting forest condition of Middle Tennessee is comprised in the plainlike stretches of heavy clay and gravel or sandy soils, such as may be seen in parts of Coffee and Warren Counties and on the Cumberland Plateau.

Although in the midst of a fine agricultural region, the thin, strongly calcareous nature of the soil seems to limit its forest growth to a few oaks and principally the characteristic black-jack (*Quercus marilandica*). This region is locally well named the "Black-Jack Lands." Many miles of level or rolling country are passed over with nothing but the heavy, glossy foliage of this peculiar oak to relieve the eye. It becomes so monotonous that even a cranky lover of trees is likely to tire in his search for some other trees. But the black-jack occasionally has an associate. The adaptive post-oak (*Quercus minor*), a few yellow oaks, and the similar Spanish oak (*Quercus digitata*) lend their presence in places where the soil passes from predominating clay to an admixture of gravel; and in the moist places the winged elm and willow-leaf oak (*Quercus phellos*) are sometimes seen. Economically the timber of this region amounts to but little, if anything, except for fire-wood, as the trees are mostly small, ranging from two to twelve inches in diameter and from ten to thirty feet in height.

The soil conditions of these districts are scarcely improved by the presence of the chief species of black-jack; for, although the stand of trees is often several hundred to the acre, apparently sufficient to shade the ground, almost everywhere a heavy growth of wild grasses covers the ground, as the narrow, dense crowns of the black-jacks nowhere form a continuous soil-cover. The hot sun—for it is occasionally hot in Tennessee—quickly evaporates all the soil moisture, and the open growth allows the sweeping winds to drive the falling leaves far from their legitimate purpose of forming a soil-improving humus.

In passing out from a brief survey of this interior red-cedar region one is apt to be struck by the fact that but very few, if any, species of pine have been seen; especially so as the pitch, long-leaf, short-leaf, Virginia scrub pine, and white pine each approach from some quarter all around. I have often asked the farmers in the red-cedar country if there were any pine-trees in their neighborhood, but I was usually told that they didn't grow there; and I recall now the surprise felt on several occasions in suddenly coming upon small islandlike clumps of short-leaf pine (*Pinus echinata*), but in most instances in the outlying counties to the south and east of the great cedar belt, where the soil conditions seem to be more fitted to pine growth than in the interior. If pines of any kind ever existed here in quantity, they seem to have long since disappeared, showing themselves far less adaptive than the cosmopolitan red cedar in taking possession of the waste limestone lands.

Leaving the middle, comparatively plain region of Tennessee and entering the eastern division of the state, the lover of trees finds much more of interest, more kinds, and a far more diversified country. Agriculture is carried on here to a more limited degree, and the natural resources of the region appear in mineral and forest wealth. From its western border of counties, just beyond the Tennessee River, to the backbone of the great Appalachian chain of mountains on the east, and from the southern to the northern border of the state, East Tennessee is one vast sea of big hill and mountain counties. Old farms nestle in the broad and narrow valleys of foothills, ridges, and mountains, and even climb the precipitous sides of the mountains, where the yellow pumpkin often seems in danger of losing its hold and descending to the valley below. Some of the finest and most productive agricultural lands exist here, while the most varied forest growth covers the hills and mountains. In the western and middle portions of East Tennessee, where the lower mountains appear, the growth of pine is a most marked feature in its abundance on the poor, dry, gravelly, and rocky slopes. But, generally speaking, there are no extensive bodies of commercial pine in this region, the old growth having long since disappeared wherever within easy reach of transportation. Except in certain localities—to be mentioned later—the second-growth pine is of comparatively small size, and often mingled with red cedar. More species of pine occur in this region of the state than in any other part, although, as distinguished from the northern white pine (*Pinus strobus*), the other pines are here usually lumped together under the names "yellow pine" or "hard pine." The possible commercial and most abundant of the pitchy pines is the short-leaf (*Pinus echinata*), which has a natural range from Maryland to Georgia and westward to eastern Texas. As is well known, it is the second most valuable of the Southern hardwood pines, ranking in commercial importance next to the famous long-leaf of more southern range. The adaptation of this pine to the poor, dry hill and other slope lands of East Tennessee is truly remarkable as seen in some localities. The old-school theories of the great care and nursing necessary to reestablish a pine-forest on entirely denuded land are quite upset when one sees thousands of short-leaf pines in dense stands steadily taking possession of old pastures and abandoned fields and quite without any foregrown nurse trees of the broad-leaf kind. Even under the damaging influence of tramping cattle and invading fire this young stock has gradually advanced. Solid phalanxes of saplings and middle-sized trees now form a large part of the second-growth woodlands attached to farms, together with oaks and other hard woods. There appears, therefore, to be no more useful concomitant in the future forestry of East Tennessee than this willingly self-propagated short-leaf pine. No one has ever planted it as a forest-tree, and when it becomes necessary for the farmers of this region to apply forestry art to the maintenance of various timber trees the problem will be easy for this pine, which is the one that should receive attention.

The next most common, but much less valuable, of the pitch pines is the Virginia scrub pine (*Pinus virginiana*), which ranges from southern New York to Georgia and westward to Middle Tennessee, where it is rather rare. In the eastern section the Virginia pine is, however, very abundant on all poor, dry knolls and other similar soils, and often associated with the red cedar and short-leaf pine. It is a small or middle-sized tree of no importance commercially, its best use being for a poor quality of fire-wood. Like the short-leaf, but to a much greater degree, the Virginia pine is eminently a tree for barren soils, defying its worst natural enemies, fire and grazing stock, and quickly clothing poor, sandy, gravelly, or rocky wastes and washed lands.

The Northern pitch pine (*Pinus rigida*) is abundant and prominent as one of the pines making up a large part of the coniferous growth which covers many of the mountain slopes. The short-leaf and Virginia pine together often occupy the foot-hills and basal areas of the mountains, while higher up the pitch pine (*Pinus rigida*) forms conspicuously large areas; or, where the soil is richer and better adapted to hard woods, the pitch pine is seen in broad, vertical, peninsularlike strips several miles away, appearing like deep shadows on the mountain-sides. The trees are usually rather small in diameter and short-trunked, not often being cut for timber.

A close associate of the pitch pine in its highest vertical distribution is the little-known Table Mountain pine (*Pinus pungens*), a tree growing naturally only from the Alleghany Mountains of Pennsylvania to the mountains of East Tennessee. It is rarely distinguished locally, and, along with the pitch pine, is commony called black pine. But its big, stout-prickled cones and two-leaved fascicles quickly distinguish it from its three-leaved associate. It usually begins high up on the rocky slopes, where the pitch pine ceases, and forms open stands of low, stunted trees, sometimes interspersed with gnarled chestnut oak (*Quercus prinus*). The sites where these pines grow is often so bare and rocky as to scarcely support any other form of vegetation, showing a great natural or acquired adaptation to dry and unfavorable situations. The short, limby trunks and usually inaccessible location of this pine allows it to grow on unmolested by the mountain lumbermen, serving the very important purpose of checking the rush of melting snow and ice.

The last of the hardwood pines, the loblolly (*Pinus taeda*), forms but a small part of the pine growth of East Tennessee, occurring chiefly and in scattering stands near the southeastern border of the state. This pine has a most abundant distribution in the South Atlantic and Gulf States.

But descending now to the lower levels of the East Tennessee mountain region, the white pine (*Pinus strobus*) found here forms an interesting feature of the forest growth. As is well known, East Tennessee and Western North Carolina form the southern limit in the distribution of this Northern pine.

Aside from professional lumbermen of the state, it is doubtless true that but few who travel through East Tennessee ever suspect that the Northern white pine exists in commercial quantities among those forest-clad mountains; but there are in some parts hundreds and in others thousands of acres of standing white pine, which would yield from five thousand to fifty thousand, and in a few localities even the astonishingly large figure of one hundred thousand, feet per acre. The bulk of this pine lies in the counties forming the northern half of East Tennessee, but extends in a more or less scattered growth clear down to the southeastern corner of the state. A great deal of the best timber has been culled years ago by portable sawmills, and considerable is being milled now at several points, while there still remains some of the finest white pine to be seen anywhere. Much of this pine is already old, in some localities has ceased to grow, and on one or two tracts I saw the best timber was rapidly dying. The peculiar soil conditions under which white pine grows in Tennessee points very strongly to an age limit of from one hundred and fifty to about two hundred years of profitable growth.

Approaching these limits, then, there are general signs of ceasing growth and final death, in no case due to natural enemies or accidental injuries. I recall now one tract of white pine in Johnson County where the timber stands in a broad alluvial valley of level and rolling land, where, at their age limit, thousands of big pines are dead and dying. This slow but sure destruction is all the more to be lamented, since this timber is of the finest quality and will give an acre-cut not excelled in any other state. Perhaps the Northern capitalists who are holding this valuable timber believe that added age will give greater value; but it should have been cut twenty-five years ago.

Compared with Northern pine land, the precise forest conditions under which white pine grows in these mountains are interesting as indicating the great adaptability of the species to varied soil and moisture conditions. The bulk of Tennessee white pine occurs alike in the narrow valleys and on the long, sharp, steep, mountain-like ridges. The vales and coves are all well watered by innumerable small streams, and the soil is a rich, clayey loam; while the ridges have a dry, rather thin, gravelly or clayey loam soil, with underlying slaty shale, in some cases entirely exposed. In rarer instances this pine occurs in deep, rich, sandy loam soils of the broad mountain valleys, in a few cases sharing with the black spruce (*Picea mariana*) the almost saturated mucky land bordering the cold-spring streams.

The regeneration of white pine in Tennessee is a most important feature of the future forestry of this section. It grows as rapidly here for its allotted time as elsewhere, and should certainly serve as a concomitant in the forests to come. The present adequate natural seeding capacity of old standing white pine is of the greatest value, if a continuance of this timber is expected. Most of the pine occurs with a dense undergrowth of oak, chestnut, hickory, maple, ash, and many smaller kinds, beneath which to-day there are millions of pine seedlings from one to ten years old. Better nurse conditions could not be wished for, and, if properly managed, the seedlings would again form a heavy stand of pine. But at this critical point lumbermen are cutting over these white pine lands as fast as they can, in some instances taking nearly everything on the land. Such rapid and complete exploitation is very and usually almost totally destructive to the tender undergrowth of pines, as no care is taken to preserve them. After the timber is taken off these cut-over lands look much as if a South Dakota cyclone had visited them. Innumerable bare lanes are cut in "snaking" out the logs, and with the quantities of dead brush and tops strewn everywhere, the trampling of grazing cattle after the incoming grass, with the inevitable torch of the careless hunter, will forever sweep away the last chance of reproducing white pine by natural seeding.

In the moister sites the white pine is almost always accompanied with large quantities of hemlock (*Tsuga canadensis*), which, by the way, is also one of the other valuable conifers of East Tennessee. In those portions of the mountains near the eastern state line, especially in the lower-lying, rich cove lands in sections where white pine is not to be found, heavy stands of hemlock often cover large areas, and form the dominant growth.

The mention of two other species completes the list of conifers found in the state, eleven in all. Nearing the high peaks of this great mountain region, large bodies of black spruce (*Picea mariana*) are found in the densest of pure growth. It is sometimes associated in limited numbers with the Southern subalpine fir (*Abies fraseri*), and very often extends down the mountain-sides among the hard woods. A thick mat of soft moss covers the underlying broken and fissured rocks where these spruces grow, and the timber stands so close that the Washington (state) elk would certainly have to take in his horns in passing through. The timber is of commercial value, both in abundance and size, and has never been touched; but lumbering at from four thousand to six thousand feet elevation requires more capital and enterprise than lower down among the white pines. Black spruce occurs mostly on the upper peaks of the mountains all along the eastern border of the state, but in a few localities may be found in small quantities scattered among lowland hard woods along streams and in wet, mucky land of the lower valleys. In still rarer instances trees are known to exist in limited numbers in the western counties of East Tennessee; in one case as far out as Grundy County.

The conspicuous but less valuable Fraser balsam, of the same relative habitat, is often found clothing the high peaks with its dark evergreen growth. It forms very dense stands on the summits, but is occasionally found lower down mingled with hard woods and spruces. For the most part this fir occurs only in the counties lying along the great divide and extends over into North Carolina. The light, soft wood of the Fraser balsam is of little or no importance commercially, being very like that of its congener, the Northern balsam fir (*Abies balsamea*). The Tennessee mountaineers gather the thick resin from the long, narrow "blisters" in the bark of this tree. The blisters are punctured and the resin allowed to run into a rude gourd bottle. Its well-known medicinal properties give it a ready sale and furnish a small revenue to the mountaineer. But our city boys would consider the money too well earned, for it takes many a blister to make an ounce and many a mile's steep, hard climbing before the trees are reached.

The spruce and fir of this region do not occur in continuous growth throughout the mountains, even along the high points of the divide, but very irregularly on isolated peaks and slopes, interrupted by laurel-covered "balds" or those timbered with hard woods. In many localities the underlying broken rock of the mountain-tops and sides has a deep soil humus, supporting a fine growth of hard woods. The cold, pure air of those heights is very similar to a Northern climate, and, as a matter of fact, many of the Northern trees and shrubs are found here. The mountain maple (*Acer spicatum*) and moose maple (*Acer pennsylvanicum*), the mountain ash (*Pyrus americana*) and mountain holly (*Ilex monticola*), appear here in larger size than in the New England and the Adirondack Mountains. The sweet and yellow birch grow to enormous size and the rose-flowered rhododendron blooms in the cool, misty shade six thousand feet above the hot plains below. Somewhat stunted in stature, even the chestnut, red and white oak, black cherry, sugar maple, ascend and cover the small, rich plateaus and ridges.

Lower down the broad mountain-slopes and deep, gorgelike coves have a forest cover of truly virgin character. In some of the eastern border counties, where railways have yet to come, the silence of those somber forest depths is scarcely ever broken by the sound of the woodman's ax. Primeval forests of centuries guard the cold crystal streams that flow on throughout the year. Bears and deer slake their thirst from the clear, bubbling pools of these streams and somewhere in their hidden, winding courses the much-hunted moonshiner brings life into the "mountain dew." When you think of the inevitable despoiling effects of the modern mill and the ax in nature so wild and untouched you sometimes wonder at the unthinking greed of man. Huge tulip-trees (poplars), with ages numbered in centuries, crowd the deep coves and rich mountain-sides with their gigantic forms. Big black cherries stare at you from their lofty heights and seem to suppress a sigh of relief when you are gone.

The sugar maple, which we expect to find in perfection only in a Northern forest, is represented here in great numbers and in the finest development; so too is the familiar beech. The little-known yellow buckeye (*Æsculus octandra*) is nowhere else surpassed in its great height and diameter growth. But the one timber tree which is worth an arduous journey to see in its greatest perfection is the almost unknown tiswood — the snowdrop, or silver bell tree, of Southern gardens, the halesia tetraptera of older botanists. For the sake of making it easier to remember, the modern upheaval in plant names has called this tree Mohrodendron carolinum. Its natural range is from the Virginias to the Gulf, where it is mostly a small tree, but rises to commercial importance in the rich mountain forests of East Tennessee. Here its common dimensions are from sixty to one hundred feet in height, with a diameter of one to four feet. Its dense, heavy, mahoganylike wood is practically unknown to commerce, but must prove to be a valuable cabinet wood.

The cucumber magnolia (*Magnolia acuminata*), a rival of the tulip-tree in the appearance and excellence of its timber, occurs plentifully and of large size in these forests, together with the much-valued white ash. It is refreshing at this day and date to see white ash trees three to five feet in diameter with sixty feet of clear trunk. You look at the rough bark of some other tall, straight trees and are surprised to find they are yellow locusts (*Robinia pseudacacia*). They are so much larger and taller than elsewhere that you do not at first recognize the common locust of fence corners. Here too the Southern white-leaved basswood grows to fine dimensions, scattered in small and large groups throughout the region. It is one of those useful trees that, to supply the present demand for excelsior, carriage, and furniture wood, it should grow in dense forests, but has an aggravating habit of occurring only in groups. The abundance of big chestnut timber in this region makes the large chestnut of the coast region look small. You lament the fact that they grow old and die in a single century, instead of growing on for future generations, like the huge red and white oaks mingled with them. Occasionally you meet a big butternut and walnut, but they appear not to be so much at home here in the mountains as in the middle section of the state. The hickories also are comparatively rare trees in these deep mountain forests, finding more congenial soil farther westward. I saw only a few pignuts and shagbarks.

In so rapid a survey of the forest flora of these two interesting sections of Tennessee I have been able to speak of only the more important commercial trees. There are many others of smaller size which make up a large part of the forest cover, but which enter but little into the commercial value of the wood products of the state. The *genera Cratægus* (hawthorn), *Prunus* (cherry) *Pyrus* (crab-apple), *Cornus* (dogwood), *Viburnum* (haw), *Aralia* (angelica-tree), *Alnus* (alder), *Magnolia, Nyssa* (gum), *Asimina* (papaw), *Ilex* (holly), *Ptelea* (quinine-tree), *Ailanthus, Æsculus* (buckeye), *Rhus* (sumach), *Gymnocladus* (coffee-tree), *Cladrastis* (yellow-wood), *Hamamelis* (wich hazel), *Liquidambar* (sweet gum) *Vaccinium* (huckleberry), *Kalmia* (laurel), *Rhododendron, Bumelia* (buckthorn), *Diospyros* (persimmon), *Catalpa, Sassafras, Platanus,* (sycamore), *Ostrya* (ironwood), *Carpinus* (hornbeam), *Salix* (willow), *Populus* (aspen), *Thuja* (cedar), are all represented in Middle and East Tennessee by a large number of species, swelling the total number of trees found in the middle and eastern sections of the state to one hundred and thirty-five species.

THE FORESTS OF TENNESSEE.*

BY J. B. KILLEBREW, A.M., PH.D.,

IMMIGRATION COMMISSIONER OF THE NASHVILLE, CHATTANOOGA, AND ST. LOUIS RAILWAY.

No problem of greater importance was ever presented to the American people than that of the preservation and reproduction of the forests of the country. The accelerating consumption of timber makes it a question of but a few years when the demand must be restricted or the supplies must be drawn from other countries than our own. At the present rate of consumption a quarter of a century will see all our grand forests denuded of their most valuable timbers. There are now more than $500,000,000 invested practically for the destruction of our forests, and not $50,000 invested for their preservation and reproduction. This simple statement shows the grave responsibility resting upon the present generation.

The area in forests in the state of Tennessee, though reported large, will be found, upon a close investigation, to be much less than is generally supposed. According to the eleventh census, Tennessee has 20,161,583 acres in farm lands, of which a little over half, or 10,799,028 acres, were classed as unimproved or in woodland. The Comptroller's report for 1896 shows 25,666,159 acres in the state reported for taxation.

The superficial area in the state, taking the number of square miles as reported by the geological survey of the United States, is 26,912,000 acres, of which there are 192,000 acres covered by lakes and rivers, leaving as the total land surface 26,720,000 acres. The difference between the number of acres reported by the Comptroller and the entire land surface of the state is 1,053,841 acres, which is, doubtless, to a large extent covered by towns, highways and railroads, and underestimates made by landowners. It will be seen, then, that the difference between the acreage reported for taxation and the acreage reported by the eleventh census is 5,504,576 acres, which may properly be credited to the wild timbered lands and coal and iron lands not attached to farms. Add these wild and mineral lands to the unimproved lands attached to farms, and it will give 16,303,604 acres nominally in timber or in abandoned lands known as old fields. Of the latter I estimate there are something near 500,000 acres. These lands consist of the worn-out hilly slopes and fields that are fenceless, or abandoned for cultivation. This leaves the wooded area of the state nominally 15,803,604 acres. But it would be misleading to suppose all this area to abound in timber trees. More than one-half of it has either been entirely denuded of its large trees, as is the case around the old charcoal furnace sites, or has been culled to furnish supplies to the more than seven hundred sawmills in the state, or to supply railroad ties and stocks for stave, heading, and wagon factories. The best estimate, therefore, of the probable area of the virgin forests in the state will not go beyond 7,000,000 acres. There is more than twice this amount unopened to cultivation, a large part of which is covered either with second-growth timber, that may, if properly protected, be valuable to future generations, or by mountain ranges in large part without timber trees.

---

*Read before the meeting of the American Forestry Association held in Nashville, September 22, 1897.

But few states in North America can show a greater variety of valuable timber trees than Tennessee. Almost every tree to be found in the United States grows in the state; and this is due partly to the great diversity of soil, partly to the great difference in elevation which gives a great difference in climatic influences, and partly to the abundant rainfall.

I have collected one hundred and thirty-seven kinds of woods, some eight or ten of them, however being exotics. Among the list of indigenous trees are four varieties of ash, three of birch, two of beech, two of magnolia, five of elm, two of fir, four of gum, eight of hickory, four of locust, three of mulberry, three of maple, four of poplar, six of pine, three of sycamore, fourteen of oak, three of willow, two of walnut, besides many single valuable kinds, such as red cedar, chestnut, cypress, cotton wood (true poplar), pecan, linden, spruce, dogwood, tiswood, etc.

Nearly all the western counties of Tennessee were originally covered with heavy forests in which many species were nearly evenly distributed. The tulip-tree (locally, poplar), the white oak, red oak, hickory, gum, black walnut, wild cherry, basswood, ash, elm, and beech are interspersed with one another, while cypress abounds in the swamps.

Hardin County contains a larger acreage of timber than any other county in West Tennessee, amounting to over 200,000 acres, and probably the forest growth in this county contains a larger number of varieties of timber than is found in any other: for in addition to the usual deciduous trees that abound in other counties, there is a large area covered with a growth of pine.

In the counties of Weakley, Hardeman, McNairy, Henderson, Carroll, Henry, and Benton there are between 150,000 and 200,000 acres in each attached to the farms. In Obion, Dyer, Gibson, Haywood, Tipton, Shelby, Fayette, and Madison Counties there are in each between 100,000 and 150,000 acres in timber attached to the farms. Dyer, Obion, Tipton, and Shelby, in this group, once contained the most densely wooded area in the United States, with the single exception of that of the state of Washington. It was not unusual to find white oak trees eight feet in diameter and poplar or tulip trees of almost equal size rising to the height of two hundred feet.

The counties of Crockett, Lauderdale, and Chester have each between 50,000 and 100,000 acres in woodland attached to farms. The excellence of the timber in Crockett and Lauderdale is not surpassed by that in any other county in the state. The large poplar log that was in the exhibit of the Nashville, Chattanooga, and St. Louis Railway at the Centennial Exposition (see cut), measuring in diameter at the larger end ten feet four inches, came from Crockett County; and, while this particular log is of unusual size and length of body, there are thousands of trees in that county, consisting of white oaks, red oaks, and poplars, that will measure from four to five feet in diameter.

Coming to Middle Tennessee, we shall find the supply of good timber very scarce in the richer agricultural districts, but in a few counties—as Perry, Wayne, Hickman, and Lawrence—lying in the southwestern portion of this civil division of the state, there is a larger area of virgin forests than is probably found in any other part of the state. Wayne and Hickman Counties have each over 200,000 acres attached to the farms, besides an equal area in wild lands or lands belonging to furnace properties and not mentioned in the census returns. Lawrence, Fentress, Humphreys, and Stewart have each between 150,000 and 200,000 acres of woodlands attached to farms, besides many large areas of mineral lands covered with a good forest growth. Montgomery, Dickson, Robertson, Davidson, Williamson, Maury, Giles, Sumner, Wilson, Rutherford, Lincoln, Warren, Franklin, and Jackson form another group that constitutes the fairest farming region in the South, presenting a land of freshness, beauty, and joyous fecundity, where the landscapes are grand, inspiring, and attractive, and are enlivened and adorned by swelling heights, sparkling streams, and rich verdure, luxuriant crops, tasteful farm-houses, and smiling villages—a land of high culture and a grand civilization, whose citizens for more than a century have, by their valor and high intelligence, inscribed their names in imperishable characters upon the keystone of American history. These counties have each yet between 100,000 and 150,000 acres in woodland, some of it still furnishing the best poplar, cedar, ash, hickory, beech, maple, oak, and sycamore timber, with here and there some elm, linden, wild cherry, locust, and walnut. Macon, Coffee, Putnam, and Cumberland have each the same area of wooded lands attached to farms as the preceding group, but they have also more than an equal area in wild lands. The timber on the wild lands in Macon, Coffee, and Putnam Counties in this group consists mainly of white oak, red oak, poplar, beech, gum, and hickory, while in Cumberland County pine, red oak, and chestnut predominate.

The remaining counties in Middle Tennessee, with the exception of Van Buren and Trousdale, have between 50,000 and 100,000 acres of woodlands attached to the farms.

Van Buren and Trousdale are both small counties, and, though the woodlands attached to the farms are less than 50,000 acres in each, yet there are considerable areas of wild lands; and this is especially true of Van Buren. where the yellow pine, black gum, white oak, and red oak are the prevailing arboreal growth.

In East Tennessee Scott County has a larger area in timber than any other county, going beyond 200,000 acres, besides a considerable quantity of wild or mineral lands. In the amount of woodlands attached to farms it stands side by side with Hardin, in West Tennessee, and with Hickman and Wayne, in Middle Tennessee.

The next group—composed of Johnson, Greene, Sevier, Monroe, and Campbell—has between 150,000 and 200,000 acres each attached to farms, and possibly as much wild land not reported by the census. Morgan, Roane, McMinn, Blount, Knox, Claiborne, Hawkins, Cocke, and Sullivan Counties have between 150,000 and 200,000 acres of woodlands reported in the eleventh census, besides an undetermined quantity of wild and mineral lands covered for the most part by forests.

All the remaining counties in East Tennessee have each attached to the farms between 50,000 and 100,000 acres of woodlands, with the exception of the small county of Hamblen, which has less than 50,000 acres of timbered lands.

The most valuable timber trees in East Tennessee are the poplar, pine, chestnut, and the oaks. The county of Scott has a large supply of poplar and oak; Morgan, Carter, Washington, Greene, Cocke, and Sevier, of white oak, white and yellow pine, poplar, red oak, and hemlock; and Johnson, of chestnut and hemlock. There is also a large amount of good timber in Sullivan, Hawkins, Hancock, Claiborne, and Campbell, consisting of nearly all the varieties of timber trees found in the state.

The rapid increase in the consumption of timber in the state of Tennessee may be inferred from the following figures, taken from the census returns of lumber-mills and sawmills for the years 1870, 1880, and 1890: In 1870 there were 702 sawmills, shingle-mills, and stave-mills, with an invested capital of $1,622,741, employing on an average 2,910 persons, paying in wages for the year $573,364, and turning out products to the value of $3,390,687. In 1880 the number of mills was 755, with an invested capital of $2,004,503; average number of employees, 3,718, who received in wages $549,222, turning out products valued at $3,744,905. In 1890 the number of mills was 789, with an invested capital of $7,186,127; number of employees, 8,004; wages paid, $2,194,615; value of products, $8,941,965. It will be seen that there was very little increase in the business between 1870 and 1880, but between 1880 and 1890, while the number of establishments increased but a little over four per cent, the capital invested increased over two hundred and fifty-eight per cent; the number of employees, one hundred and twenty per cent; and the amount of wages paid, three hundred per cent., while the value of the products increased one hundred and thirty-nine per cent. From these comparisons two facts are deducible: 1. That the capacity of the mills has increased during the past decade more than one hundred per cent. 2. That the wages of the employees have been increased eighty per cent, while the value of products, per capita, has been increased a little less than ten per cent.

The number of feet of logs purchased by mills for the census year in Tennessee was 2,854,674,000, and the amount obtained by the mill-men in the woods was 141,206,000, at a total cost of $4,615,269.

The amount of furniture stock obtained in the state for the census year was 6,644,000 feet, at cost of a little over $16.32 per thousand feet, amounting to $108,418. The sawed lumber amounted to 450,097,000 feet, at an average value of $12.50 per thousand feet, making a gross valuation of $5,678,762. The number of shingles made in the state was 19,537,000, valued at $41,017; staves, 60,490,000, valued at $589,200; headings, 8,675,783 sets, valued at $157,507. Besides these items, there was a vast number of handles, spokes, hubs, bent work, etc.

Since 1890 the lumbering business of the state has increased with great—and, I may say, with alarming—rapidity. Estimates made from careful inquiry lead me to believe that the number of establishments now in the state is fifty per cent greater than they ever were in its previous history; nor is the end yet reached, for nearly every week shows some new lumbering-mill, stave-mill, or shingle-mill erected or planing-mill established. I have no means by which to estimate with any degree of certainty the number of logs now cut or the amount of lumber now made in the entire state, nor have I been able to procure the statistics for hubs, spokes, handles, etc., for the whole state of Tennessee, but I find that the production for the year 1896, along the line of the Nashville, Chattanooga, and St. Louis railway, was as follows: Spokes, 6,750,000; handles, 594,000; hubs, 60,000; rims, 102,000; neck-yokes, single-trees, etc., 750,000. This is about three-fourths of the production in the state.

The number of staves made along this line for the year 1896 was 240,000,000, which is four times as many as was made in the state in 1890. Most of these are made on the northwestern division and branches of the Nashville, Chattanooga, and St. Louis railway, where there are now fifty-seven stave-factories in operation. The whole number of staves made in this region in 1873 was only 1,650,000. The increase has been one hundred and forty-five fold.

The value of exports of lumber and forest products from the United States for the year ending June 30, 1897, was $39,624,800, as against the value of $31,947,108 for the year previous, an increase of twenty-four per cent. The average value of board deals and plank for the month of June was $16.13 per thousand feet, which is an increase of $1.39 over the average value of the preceding two years, and $2.21 over the average for the years 1896-97.

For many years Nashville was the largest hardwood market in the world, but recently both St. Louis and Chicago have gone ahead of it, and it now stands third.

The average shipments of lumber from Nashville now amount to 27,000,000 feet annually. Of this amount 15,000,000 is poplar, 7,000,000 feet oak, and 5,000,000 feet ash and other woods. About 60,000,000 feet are carried in stock in the Nashville market.

It is evident that the destruction of forests in the state of Tennessee is growing with increasing rapidity. While the state has yet an ample supply of timber, it is every year becoming apparent that some legislation is demanded for its preservation and reproduction. What shall this legislation be?

First, there should be a severe punishment inflicted on all persons who wilfully or maliciously set the woods on fire. From time immemorial it has been the custom of those living in thinly settled regions to burn off the leaves from the wooded lands in order that the wild, coarse grasses may spring up and supply pasturage for domestic animals, and especially for cattle and sheep. There is no record of the damage done to the forests in Tennessee by such fires later than for the year 1880, when the census reports showed that 985,420 acres of timber were thus destroyed. Of these destructive fires, nineteen per cent came from burning off the woods in order that the early grass might come. An equal percentage of fires resulted from the burning of brush in clearing lands. Six per cent was charged to railway locomotives; fourteen per cent from hunters' camps; fourteen per cent from malicious persons, and one per cent from smoking. This is a serious loss to the people of Tennessee, amounting in one year to about six per cent of the entire wooded area of the state. No doubt the percentage is much larger than that reported, for from many of the districts in the state no returns whatever were made.

The loss of the timber does not cover the damage done to the soil by the destruction of leaves, humus, and undergrowth. The forests of the future are swept away, and even the seeds and germs of plants are destroyed. Careful inquiry as to the damaging effects of forest fires in Michigan lead me to believe that the value of the timber is scarcely one-half of the loss sustained by such fires in that state. It is a rare thing to see in any burnt district other growth than dwarf birch, hemlock, scrub oaks, and other shrubs of no value whatever. Indeed, scarcely any crop will grow vigorously when planted on a burnt district in Michigan. I do not believe that fires injure the productive capacity of the soils in Tennessee, but they doubtless impair the durability of the soils.

Great damage is done to the forests by browsing animals. This damage arises from two causes: 1. The trampling of the land, which impairs the vitality of the trees and causes many of them to die. 2. Myriads of small trees, which are the embryo forests of posterity, are killed by being stripped of their leaves and bark by the browsing animals. Hogs often destroy young pines by rooting them up in order to feed upon the succulent roots. It is scarcely a question of doubt that the highland pasturage of Tennessee, causing as it does the destruction of so much young timber, costs the state every year more than all the stock is worth that feeds upon such pasturage.

No more land, especially in the thickly settled districts of the state, should be opened for cultivation. The ax of the pioneer has done its work. The present generation should restore and build up the waste places, take steps to reproduce the timber upon all spots unfit for tillage, and carefully preserve the vigor of all forests by only cutting out the decayed timber and trees that have attained their probable full value for lumber. There should be a greater economy practised in the use of timber. Fences in the future should be built of wire, and locust or cedar trees should be planted all along the line of such fences to serve as posts. Coal is now so cheap that it should be used for domestic purposes in the place of wood whenever it can be had at a price not exceeding ten cents per bushel.

More than a quarter of a century ago I suggested that all old fields in the state that had been abandoned on account of their sterility and all steep slopes in the fields liable to wash should not be taxed for a period of ten years, provided that the owners of such spots and old fields would plant them in timber and cultivate the same until the trees should become firmly established and reach a condition of vigorous vitality. This idea was warmly embraced by many progressive thinkers in the state, but unfortunately the provision in our state constitution directing that all property shall be equally taxed, with certain named exceptions only, made it impossible for the Legislature to act upon the suggestion.

Should a constitutional convention ever be called, this question of the reproduction of our forests should receive due consideration and should be encouraged by granting exemptions from taxation of all such lands as are planted in timber and cultivated in a prescribed manner. My estimate that there are 500,000 acres of such land in the state is not excessive; and could this large, worthless acreage be made fruitful of timber for the uses of our posterity, we shall do much to awaken their gratitude and give to them a just regard for and a proper conception of our wisdom. Were these places broken up and sown in acorns or hickorynuts, or planted with small locusts, the effect would in every way be salutary. The land would be reclaimed; what is now valueless would become valuable; the hideousness of the landscape would be converted into beauty and blooming attractiveness. A spot for the retention of moisture would be created, and a small tax-paying property converted into one that would contribute largely to the revenues of the state.

The natural wealth of every state depends primarily upon its timber and soils, and it should be the highest and most solemn duty of our lawmakers to look beyond the present and to enact such laws and pursue such a policy as will in the end conduce to the wealth, greatness, and glory of the state and the prosperity of her citizens; and in no way can this be more effectually done than by taking steps for the reclamation of the soil and the preservation of the timber. Had this been done fifty years ago, Tennessee would not now be dotted all over with repulsive and haggard old fields that constitute the shame and mark the shiftlessness of her farmers. A new departure is called for in this particular, and he who shall be instrumental in restoring the lost fertility of these waste places and making them things of beauty and profit may well be numbered among the benefactors of mankind.

The press in the various parts of the state should take up this subject, discuss it in detail, encourage the enactment of such constitutional provisions as will remove present hindrances, and press the matter before the people until pride, taste, interest, ambition, the highest wisdom, and an enlightened public sentiment shall unite in building up these sterile places.

Enough of such spots there are, if reclaimed, to build a first-class railroad through the state.

More is involved in this question than mere money. The very existence of the human race is imperiled by this neglect. Happiness, contentment, progress, refinement, and true civilization depend, in a measure, upon the preservation of our forests, which greatly affect climate, and the preservation of our soils, which so greatly affects production and population.

Nor should the railroads, with all their influence and accumulated wealth, fail to give encouragement in every possible way to the preservation and reproduction of our forests. For the period of eleven years the Nashville, Chattanooga, and St. Louis railway has consumed annually 370 ties on an average for each mile of main track. This includes also the requirements for about 195 miles of new track in eleven years. The consumption for the state on this basis would reach 1,147,000 ties, requiring 38,232 acres annually to supply.

The life of the railroad ties in Tennessee is greater than the average life of ties in the whole country for two reasons—viz., (1) the ties are larger and made altogether from selected trees, and they are smoothly hewn; (2) the traffic is not so heavy as the average traffic of the whole country, and ties are not subjected to such frequent use in carrying large burdens.

The railroads of the country are annually consuming 90,000,000 ties. If the life of railroad ties for the entire country could be extended to the limit reached by the ties of the Nashville, Chattanooga, and St. Louis railway, which is about eight years, 67,000,000 ties only would be required for the annual consumption of the 182,000 miles of railroads in the United States, instead of 90,000,000.

The total consumption for railroad purposes in the United States, which includes ties, trestle and culvert timber, timber for cars, etc., is estimated to be 500,000,000 cubic feet, or 6,000,000,000 feet board measure. Estimating 6,000 feet of merchantable timber to the acre, which must be regarded as liberal, it will require 1,000,000 acres of timber annually to supply the needs of the existing railroads in the United States.

This large consumption of timber for ties is a serious drain upon the forests of the country, requiring 45,000,000 trees, on the assumption that an average of two ties may be had from one tree. Fifteen trees to the acre suitable for making ties would be a full estimate, so that it will require the culling of 3,000,000 acres a year to supply this demand. The right of way held by the 182,000 miles of railroads of the United States, assuming the width of one hundred feet, take up not less than 2,172,000 acres. If this were planted in locust-trees or catalpa, so as to form one row of trees on each side of the track, fifty feet distant from the track, the trees being set four feet apart, it would give room to grow 477,840,000 trees, which ought to make 900,000,000 ties. The life of black or yellow locust ties is from seven to ten years. With proper culture and attention these locust-trees would be large enough in fifteen years to make railway ties. This would supply an annual average of 60,000,000 ties. This is about two-thirds the number necessary to meet the present requirement of the railroads of the United States. It would be wisdom in the management of the railway lines to utilize their right of way in this manner.

It is a false patriotism to rob posterity of their natural rights, and not to protect the timber of our state is a crime against civilization and a crime against posterity. Our present destructive methods combine the stupidity of unthinking barbarism and the cupidity of unprincipled selfishness with the wantonness of unbridled license. Forests are the breathing-places of mother earth, the beautiful vestments that hide her nudity and decorate her person. Forests, indeed, play a most wonderful and important part in the economy of nature. They temper the severity of the wintry blasts, they give a grateful freshness to the summer breezes, they regulate the flow of our rivers, and keep our springs from drying up; they shield the earth and protect it from the deep freezes in winter, they induce a regularity in the rainfall; their verdure beautifies the land, their leaves fructify the soil, and their shade adds a genial quality to every home.

U.C. BERKELEY LIBRARIES
C032629024

338455
SD 144
T5 P3
v.1
UNIVERSITY OF CALIFORNIA LIBRARY